THE 30TH JAIF ANNUAL CONFERENCE

第30回原産年次大会

APRIL 9～11, 1997

JAPAN ATOMIC INDUSTRIAL FORUM

日本原子力産業会議

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第30回原産年次大会プログラム

基調テーマ：原子力ー今、本音で語るとき
平成９年４月８日(火)～１１日(金)
於　東京国際フォーラム　ホールC

	第１日（４／９）	第２日（４／１０）	第３日（４／１１）
午前	開会セッション (9:00～12:00) 原産会長所信表明 原子力委員会委員長所感 大会準備委員長講演 <特別講演>午前の部	第30回大会記念シンポジウム 「改めて原子力開発のあり方を問う」 [社会討論] (9:00～12:00) 原子力はなぜ「迷惑施設」といわれるのか	セッション２ (9:00～12:00) エネルギーの廃棄物にいかに対処するか
	午餐会 (12:15～14:00) 於 ホールB 原子力映画上映 (13:00～14:00)	昼休み [緊急報告] (13:00～13:50) 動燃・東海アスファルト固化処理施設の火災・爆発事故	昼休み
午後	(14:15～14:45) <特別講演>午後の部 セッション１ (14:45～17:45) 代替エネルギーの役割と未来	[政治討論] (14:00～16:30) 原子力開発の新しい進め方を問う	セッション３ (13:30～17:00) アジアが必要とする地域協力とは
		[市民の意見交換] くらしとエネルギー ーどうして原子力？ (17:00～　　) 於 レセプションホール	

レセプション
(4/8 19:00～20:30)

於　帝国ホテル

<登録受付：18:15～>

[4月8日(火)]

レセプション（19:00〜20:30）

於 帝国ホテル 本館2階「孔雀の間(東西)」
（登録受付は18:15から「孔雀の間」前で行う。）

[4月9日(水)]　受付開始 8:15

開会セッション（9:00〜14:45）

議長：渡　辺　文　夫　(社)日本原子力産業会議副会長

原産会長所信表明
　向　坊　　隆　（社）日本原子力産業会議会長
原子力委員会委員長所感
　近　岡　理一郎　原子力委員会委員長
　　国務大臣･科学技術庁長官
大会準備委員長講演
　田　原　総一朗　評論家

＜特別講演＞　午前の部　(10:00〜12:00)

議長：近　藤　次　郎　（社）日本原子力産業会議副会長

「世界の安全保障の展望、および２１世紀における核兵器の役割」
　R．マクナマラ　元米国国防長官、元世界銀行総裁
「２１世紀をどう生きるか」
　諸　井　　虔　秩父小野田(株)取締役相談役、経済同友会幹事
「創られた恐怖：大きな恐れ…しかし小さなリスク」
　E．M．フェラン　科学と健康に関する全米会議会長

＜参加者との意見交換＞

午　餐　会（12:15～14:00）

於 東京国際フォーラム ホールB

通商産業政務次官所感

石　原　伸　晃　　　　通商産業政務次官

＜特別講演＞

「東と西の融合」

森　　　英　恵　　　　デザイナー（文化勲章受章）

原子力映画上映（13:00～14:00）

於 東京国際フォーラム ホールC

＜特別講演＞　午後の部　（14:15～14:45）

議長：安　部　浩　平　　(社)日本原子力産業会議副会長

「原子力発電の現在と未来」

V．ミハイロフ　　　　ロシア原子力省大臣

「中国の原子力開発の進展」

李　定　凡　　　　　中国核工業総公司副総経理

<u>セッション１（14:45〜17:45）</u>
代替エネルギーの役割と未来

世界のエネルギーの需要は今後、省エネルギーやエネルギー利用の効率化に最大限に努力するとしても、増大することは避けられない。一方、エネルギー利用に伴う環境影響は深刻化してきており、環境への負荷が小さいエネルギー源の開発、導入が真剣に求められてきている。ここでは、世界のエネルギー需給を展望しつつ、人類の将来のために最適で安定なエネルギー供給確保を目指して、化石燃料に代わるエネルギー源の見通しと役割について議論する。

議長：今　井　隆　吉　　　杏林大学教授

＜基調講演＞

「世界が直面するエネルギー安全保障問題」

W. マーチン	元米国エネルギー省副長官

＜パネル討論＞

パネリスト

J. M. ブデール	経済協力開発機構/国際エネルギー機関（ＯＥＣＤ/ＩＥＡ） 長期協力・政策分析局長
藤　井　石　根	明治大学理工学部教授
藤　目　和　哉	(財)日本エネルギー経済研究所常務理事
W. マーチン	(前　出)
K. シラパバンレン	タイ・チュラロンコン大学エネルギー研究所長

<参加者との意見交換>

[4月10日(木)]

第30回大会記念シンポジウム
「改めて原子力開発のあり方を問う」

社 会 討 論 (9:00〜12:00)
原子力はなぜ「迷惑施設」といわれるのか

原子力施設の建設をめぐる状況は、乖離する生産地と消費地の位置づけの問題なども含め、ますます複雑化している。従来の立地に係る諸方策も、社会の変化に伴い次第に実状にそぐわなくなってきており、原子力が地域社会と共生していくためには、新たな努力が求められている。ここでは、原子力がなぜ迷惑施設といわれるのかを明確にし、原子力施設立地における社会的公正、原子力発電都市立地の可能性等を踏まえながら、今後のあり方について討論する。

議長：鳥　井　弘　之　　日本経済新聞社論説委員

＜基調講演＞

「原子力施設が嫌われるこれだけの理由」

高　木　仁三郎　　　原子力資料情報室代表

＜パネル討論＞

パネリスト

小木曽　美和子	原子力発電に反対する福井県民会議事務局長
内　藤　信　寛	柏崎商工会議所専務理事
J.P.ショウサッド	フランス電力公社経営執行局技術顧問
高　木　仁三郎	(前　出)
舛　添　要　一	国際政治学者

コメンテーター

石　谷　清　幹　　　大阪大学名誉教授

<参加者との意見交換>

緊 急 報 告（13:00～13:50）

動燃・東海アスファルト固化処理施設の火災・爆発事故

去る３月１１日（火）、動力炉・核燃料開発事業団東海再処理施設の低レベル放射性廃棄物アスファルト固化処理施設において火災ならびに爆発事故が発生した。人的被害は生じなかったものの、同施設が核燃料リサイクルの中核となる再処理施設の一部であったこととも合せて、社会的に大きな反響を巻き起こした。ここでは現時点までの調査に基づき、施設の被害の状況や環境への影響など事故の概況について動燃から報告を受け、質疑応答を行う。

進行：坂　本　　俊　　(社)日本原子力産業会議理事・事務局長

＜報　告＞

植　松　邦　彦　　動力炉・核燃料開発事業団副理事長

中　野　啓　昌　　動力炉・核燃料開発事業団理事

＜質疑応答＞

政 治 討 論（14:00～16:30）
原子力開発の新しい進め方を問う

昨今、原子力開発に対する認識は大きく変化している。原子力開発を取り巻く情勢を見ると、国民生活の質や環境に対する意識が高まりを見せ、種々の政策決定に対する直接的関与が求められるなど、計画推進上考慮すべき要因が多岐にわたって生じつつある。今後はこうした変化に対応しつつ、より大きな視点に立ったエネルギー政策の展開が望まれる。ここでは、今後の日本における原子力の位置づけと新エネルギーの役割、地域分権等が進む中での原子力発電所立地へのコンセンサスづくりのあり方、原子力発電所立地の新しい施策、アジアのエネルギー需要・環境汚染問題等への日本の対応策などについて、主要な政党の代表者等による討論を行う。

議長：田　原　総一朗　　評論家

＜パネル討論＞

パネリスト

山　崎　　拓	自由民主党 衆議院議員政務調査会長
伊　藤　　茂	社会民主党 衆議院議員幹事長
聴　濤　　弘	日本共産党 参議院議員政策宣伝委員会責任者
野　田　　毅	新進党 衆議院議員政策審議会長
仙　谷　由　人	民主党 衆議院議員政策調査会長

<参加者との意見交換>

市民の意見交換（17：00～　　　　）
くらしとエネルギー：どうして原子力？

於 東京国際フォーラム レセプションホール

安定的な市民生活を継続していくためにはエネルギーの供給が不可欠であるが、地球環境をめぐってエネルギー利用のあり方が問われている。代替エネルギーの中心として開発されてきた原子力についてもその安全性や進め方に関し、信頼感が失われつつある。ここでは、広く一般市民の参加を求め、これらの人々と原子力開発関係者が一堂に会し、市民としての立場で自由な意見交換を行い、原子力の直面する課題を明らかにし、くらしが求めるエネルギー供給のあり方とは何かを考える。

司　会
　田　村　和　子　　　　共同通信社論説委員

コーディネーター
　森　　一　久　　　　　(社)日本原子力産業会議副会長

なお、特別コメンテーターとして、田原　総一朗氏（年次大会準備委員長）、また、議論の展開に資するため、高木　仁三郎氏（原子力資料情報室代表）、下村　満子氏（ジャーナリスト）、中島　篤之助氏（前中央大学教授）等にもご出席いただきます。

[4月11日(金)]

セッション2（9:00〜12:00）
エネルギーの廃棄物にいかに対処するか

原子力は環境への負荷が小さいエネルギー源ということで開発されてきた。地球環境への関心が高まっている今日、エネルギーと環境との関係が新たに問われており、特に原子力の場合は、放射性廃棄物が今後の課題として注目されている。ここでは、各種エネルギー源から発生する廃棄物の問題に焦点をあて比較討論し、廃棄物管理の観点から原子力の位置づけを探るとともに、放射性廃棄物処理処分の見通しを明らかにし、国際協力を含む対応のあり方について討論する。

議長：深　海　博　明　　慶應義塾大学経済学部教授

＜基調講演＞
「エネルギー、環境、廃棄物」
　G．マーシュ　　英国貿易産業省エネルギー技術支援機関理事・戦略研究本部本部長

＜パネル討論＞
パネリスト
　M．フォルガー　　原子力産業放射性廃棄物管理会社（ＮＩＲＥＸ）社長（英国）
　中　島　篤之助　　前中央大学教授
　鷲　見　禎　彦　　関西電力㈱副社長
　高　橋　　誠　　経済協力開発機構/原子力機関（OECD/NEA）事務次長
　A．ゾボフ　　ｶｰﾈｷﾞｰ平和基金ﾓｽｸﾜｾﾝﾀｰ上級顧問・核物質管理学会ﾛｼｱ支部会長

コメンテーター
　品　川　尚　志　　日本生活協同組合連合会常務理事
　鈴　木　勇　吉　　(社)全国産業廃棄物連合会会長

<参加者との意見交換>

セッション３（13:30～17:00）
アジアが必要とする地域協力とは

高い経済成長を続けるアジアでは、それを支えるための電源確保と環境保全の見地から、原子力発電を選択し、その開発計画を積極的に進めており、２１世紀の早い時期に運転中の発電所の数も１００基を超えることが予測される。同地域への欧米原子力産業の進出は活発化している一方、日本の協力の必要性も今後増大すると考えられる。アジアの原子力発電開発の円滑な進展は、世界のエネルギー問題や地球環境問題を解決していく上で重要である。ここでは、既存の地域協力を評価しつつ、安全性、放射性廃棄物の取り組み、平和利用の担保等を念頭に、今後の地域協力のあるべき姿を模索しながら討論する。

議長：植　松　邦　彦　　動力炉・核燃料開発事業団副理事長

＜基調講演＞
「私がえがく“アジアトム”」
村　田　　浩　　（社）日本原子力産業会議副会長

＜パネル討論＞
パネリスト
Ｅ．フェイ　　米国エネルギー省核不拡散安全保障局国際政策分析室室長代理
洪　周　甫　　韓国電力公社原子力発電處處長
Ｂ．ラーソン　　ＣＲＡ社国際部長（オーストラリア）
Ｙ.Ｓ.Ｒ.プラサド　　インド原子力産業会議会長
Ｉ．スブキ　　インドネシア原子力庁（ＢＡＴＡＮ）長官
鈴　木　篤　之　　東京大学工学部教授

＜参加者との意見交換＞

Program of the 30th JAIF Annual Conference

April 8－April 11, 1997
Hall C, Tokyo International Forum
(As of April 1, 1997)

Main theme: Nuclear Energy－Let's Talk Now

TUESDAY, APRIL 8

REGISTRATION(18:15－) & WELCOME RECEPTION (19:00－20:30)
at Peacock Room, Imperial Hotel

WEDNESDAY, APRIL 9

REGISTRATION(8:15－) at Hall C, Tokyo International Forum
OPENING SESSION (9:00－12:00)

Chairman:
Fumio Watanabe — Vice Chairman, Japan Atomic Industrial Forum

JAIF Chairman's Address
Takashi Mukaibo — Chairman, Japan Atomic Industrial Forum

Remarks by Chairman of the Atomic Energy Commission of Japan
Riichiro Chikaoka — Chairman of the Atomic Energy Commission
State Minister for Science and Technology

Remarks by Chairman of the Conference Program Committee
Soichiro Tahara — Journalist; Chairman of the Program Committee

Chairman:
Jiro Kondo — Vice Chairman, Japan Atomic Industrial Forum

Lectures:
"A Vision of Global Security, and the Role of Nuclear Weapons in the Twenty-first Century"
Robert McNamara — Former U.S. Secretary of Defense
Former President of the World Bank

"We in the 21st Century"
Ken Moroi — Advisor, Chichibu Onoda Cement Corp., Japan

"Toxic Terror: Big Fears...But Little Risks"
Elizabeth Whelan — President
American Council on Science and Health, U.S.A.

Discussion with the floor

LUNCHEON (12:15－14:00)
at Hall B, Tokyo International Forum

Remarks by Minister of International Trade and Industry
Shinji Sato Minister of International Trade and Industry, Japan

Special lecture:
"Fusion of the East and the West"
Hanae Mori The Order-of-Culture conferred designer, Japan

FILMS ON NUCLEAR ENERGY (13:00－14:00)
at Hall C, Tokyo International Forum

14:15－14:45
Chairman:
Kohei Abe Vice Chairman, Japan Atomic Industrial Forum

Lectures:
"Nuclear Power Today and Tomorrow"
Victor Michailov Minister of the Russian Federation on Atomic Energy

"The Progress of China's Nuclear Energy Program"
Dingfan Li Vice President
China National Nuclear Corporation

SESSION 1 (14:45－17:45) " Alternative Energies: Roles and Prospect"

The world energy is inevitably bound to increase, despite our efforts for energy conservation and efficient use of energy. Environmental effects of energy use are becoming more severe, making it imperative to develop and introduce energy sources of limited environmental impact. This session deals with prospects for and roles of fossil fuel-alternative energy sources for an appropriate, stable energy supply.

Topics:
- World energy demand and future outlook
- Status of and prospects for new energy source development
- Roles of nuclear and new energies, etc.

Chairman:
Ryukichi Imai Professor, Kyorin University, Japan

Keynote address:
"Energy Security Issues Facing the World"(tentative)
William Martin Former U.S. Deputy Secretary of Energy

Panel discussion:

Jean-Marie Bourdaire	Director Office of Long-term Cooperation and Policy Analysis OECD International Energy Agency
Iwane Fujii	Professor, Meiji University, Japan
Kazuya Fujime	Managing Director Institute of Energy Economics, Japan
William Martin	Same as above
Kulthorn Silapabanleng	Director of Energy Research Institute Chulalongkorn University, Thailand

Discussion with the floor

THURSDAY, APRIL 10

THE 30TH ANNUAL CONFERENCE SPECIAL SYMPOSIUM
"Reexamining What Nuclear Power Development Should Be"

Social Debate (9:00 – 12:00) "Why Are Nuclear Power Facilities Regarded 'Unwanted'"

Siting nuclear facilities has become a complicating issue, as a divergence of power-producing and power-consuming areas. The various schemes originally developed for siting have gradually grown inappropriate as society has changed. Efforts are required anew to allow nuclear power to coexist with local communities. This debate clarifies the reasons for nuclear power facilities to be regarded nuisance and develops possible solutions.

Topics:

- How social fairness can be pursued in nuclear power siting
- Why nuclear power facilities are not accepted
- The perception gap between siting and energy consuming areas
- Conditions allowing urban siting of nuclear power plants, etc.

Chairman:

Hiroyuki Torii	Editorial Writer Nihon Keizai Shimbun, Inc., Japan

Keynote address:
"So Many Reasons for Nuclear Facilities Being Deemed Unacceptable"

Jinzaburo Takagi	Executive Director Citizens' Nuclear Information Center, Japan

Panel discussion:

Jean-Pierre Chaussade	Technical Advisor Communication Division Electricite de France
Yoichi Masuzoe	Political Scientist, Japan
Nobuhiro Naito	President The Kashiwazaki Chamber of Commerce & Industry, Japan
Miwako Ogiso	Secretary General Council of the People of Fukui Prefecture against Nuclear Power
Jinzaburo Takagi	Same as above

Commentator:

Seikan Ishigai	Professor Emeritus Osaka University, Japan

Discussion of the floor

Political Debate (14:00－16:30) "Examining the Ways to Develop Nuclear Power"

The perception of nuclear power development has greatly changed in recent years. The public has come to demand a more direct role in various decision-making processes, as living standards have improved and environmental concerns have heightened. That gives rise to a greater number of factors demanding consideration when plans are being set forth. From now on, nuclear power policies must be formulated from a broader standpoint than before. This debate features representatives from Japan's major political parties, who will explore ways to carry out nuclear power development.

Topics:

- Future prospect of nuclear power in Japan (MOX, etc.) and the share of new energies in the total energy mix
- How to build a consensus for nuclear siting in increasing autonomous local face of power
- New policies for nuclear power siting
- Japan's response to increasing energy demand and environmental pollution in Asia
- Reforming governmental bureaucracy for nuclear power development, etc.

Chairman:	
Soichiro Tahara	Journalist; Chairman of the Program Committee
Panel discussion:	
Taku Yamasaki	Liberal Democratic Party
Shigeru Ito	Social Democratic Party
Hiroshi Kikunami	Japan Communist Party
Takeshi Noda	New Frontier Party
Yoshito Sengoku	Democratic Party of Japan

Discussion with the floor

Dialogue with the Public (17:00－) "Life and Energy: Why Nuclear?"

If the human society pursued the current standards of living, energy use should be compatible with the environmental conservation. Nuclear power, developed as a primary alternative energy source to fossil fuels, has been losing public trust with the safety and policy concerned. This session is aimed to call for large public participation meet and exchange their views with nuclear professionals directly. The focus is on squarely facing the issues of nuclear power, questioning a kind of energy supply that today's lifestyle requires.

Topics:

- Are nuclear power facilities safe enough?
- Information disclosure at nuclear power plants, etc.

Moderator	
Kazuko Tamura	Senior Writer & Editorial Writer Kyodo News Agency
Coordinator:	
Kazuhisa Mori	Vice Chairman, Japan Atomic Industrial Forum
Commentators:	
Soichiro Tahara	Journalist; Chairman of the Program Committee
Tokunosuke Nakajima	Former Professor, Chuo University, Japan
Mitsuko Shimomura	Journalist, Japan
Jinzaburo Takagi	Executive Director Citizens' Nuclear Information Center, Japan

FRIDAY, APRIL 11

SESSON 2 (9:00-12:00) "Managing Waste Products from Energy"

Nuclear power has been developed as an energy source with little environmental burden. Today, with environmental concerns heightening, the effect of energy generation on environment is drawing more attention. For nuclear power, particularly, management of radioactive wastes has become an important issue . This session takes a comparative look at wastes of various energy sources, contesting nuclear power in its waste management as well as presenting an outlook for radioactive waste disposal.

Topics:

- Outlook and evaluation of wastes from various energy sources
- Significance of nuclear power from a point of environmental protection
- Current state of and outlook for radioactive waste disposal, etc.

Chairman:

Hiroaki Fukami	Professor of Economics, Keio University, Japan

Keynote address:

"Energy, Environment and Waste"

George Marsh	Manager, Strategic Studies Department Energy Technology Support Unit, U.K.

Panel discussion:

Michael Folger	Chief Executive, U.K. Nirex
Tokunosuke Nakajima	Former Professor, Chuo University, Japan
Yoshihiko Sumi	Director & Executive Vice President Kansai Electric Power Co., Ltd., Japan
Makoto Takahashi	Deputy Director for Safety and Regulation OECD Nuclear Energy Agency
Andrei Zobov	Senior Associate Carnegie Endowment for International Peace; Chairman, Russian Chapter Institute of Nuclear Materials Management, Russia

Commentators:

Hisashi Shinagawa	Executive Director Japanese Consumers' Cooperative Union
Yukichi Suzuki	President, National Federation of Industrial Waste Management Associations, Japan

Discussion with the floor

SESSION 3 (13:30－17:00) "Regional Framework for Nuclear Developing Asia"

For the booming economies in Asia to grow at current rates, it is essential for them to secure the necessary power sources while protecting the environment. Many countries in the area have chosen to introduce nuclear power, and are actively involved in its development. Early in the next century, more than 100 nuclear power units are expected to be in operation in the area. With Western nuclear companies stepping up activities in Asia, Japan should increasingly be interested in its further cooperation. Whether Asian nuclear power development can progress will have great bearing on global energy and environmental problems. This session discusses a cooperative regional framework for Asian nuclear energy development, with respect to its potential and requirements to be met.

Topics:

- Outlook for nuclear power development in Asia
- What kind of regional cooperation is necessary?
- Issues facing current regional cooperation (KEDO, PBNC, etc.), etc.

Chairman:

Kunihiko Uematsu	Executive Vice President Power Reactor and Nuclear Fuel Development Corp.

Keynote address:
"ASIATOM—A Personal View"

Hiroshi Murata	Vice Chairman, Japan Atomic Industrial Forum

Panel discussion:

Edward Fei	Deputy Director for Policy International Policy and Analysis Division Office of Non-proliferation and National Security U.S. Department of Energy
Bruce Larson	General Manager, External Affairs CRA, Australia
Y.S.R. Prasad	Chairman, Indian Atomic Industrial Forum
Chang-Saeng Shim	Vice President International & North Korea Project Div. Korea Electric Power Corporation
Iyos Subki	Director General National Atomic Energy Agency (BATAN), Indonesia
Atsuyuki Suzuki	Professor, University of Tokyo, Japan

Discussion with the floor

第三十回原産年次大会会長所信表明

平成九年四月九日(水)
(社)日本原子力産業会議
会長　向坊　隆

議長、ご臨席の皆様、日本原子力産業会議会長の向坊でございます。

第三十回原産年次大会の開催にあたりまして、主催者を代表して、一言所信を述べさせていただきます。

はじめに、国の内外から多数の方々がこの大会にご参加くださいましたことに、心から厚く御礼申し上げます。

さて、冒頭に触れましたように、原産の年次大会も三十回目の記念すべき大会を迎えました。第一回の大会は一九六八年の三月に開催されましたが、その時東京大学の教授でありました私は、原子力施設の安全性について講演を致しました。当時わが国において次々と軽水炉の建設が開始され、国産化計画が進んでいたこともあり、参加された方々を前にして、いよいよわが国も民間が総力を挙げて原子力の商業利用に取り組みはじめた熱気を実感したことを、昨日のことのように思い出します。記録によりますと、その第一回の参加者は六〇〇名足らずであったそうですが、今日一四〇〇名を超える国内外の、しかも多様な分野の方々がここに御集まりいただいていることを目の当たりにいたしまして、わが国における原子力開発の大きな進展に、感慨を新たにしている次第であります。

原産年次大会は当初からできるだけ多様な方々に参加していただいて、科学技術やエネルギー供給の問題にとどまらず、政治的、社会的な視点も入れて、原子力開発に関わる広範な議論を展開することをねらいとしてきました。とりわけ近年におきましては、一般市民の方々にも参加を呼びかけ、私達の議論に加わっていただけるように心がけてきました。本大会は三十回の節目と言うこともあり、また昨今、原子力開発をめぐる世論の情勢が大変厳しいことにも鑑みまして、大会の準備委員長を評論家の田原総一朗さんにお願いし、従来の原子力開発の進め方に批判的であられた方や、中立的なジャーナリストの方々などにも委員としてご参画いただき、大会をさらに開かれたものにしたいと考え

ました。本大会のねらいやプログラムにつきましては、後ほど田原委員長が講演のなかで触れられると思いますが、委員の皆様の真剣なる審議によりまして、私の期待を超える内容になったと思います。

さて、只今申し上げました通り、わが国の原子力開発をめぐる国民世論は大変厳しいものがあります。一昨年十二月の高速増殖炉原型炉「もんじゅ」のナトリウム漏洩事故や、この三月十一日に起きた動燃東海・低レベル放射性廃棄物アスファルト固化施設の事故が、その一因であることは疑いのないところであります。我が国が原子力開発の本来の目的としてきた核燃料リサイクルの確立にむけて大きく踏み出そうとしている時に、このような失敗があり、原子力開発に対する国民の信頼を損ねる結果になったことは、まことに残念であります。動燃のアスファルト固化施設の事故によって環境に放出された放射性物質は微量であり、人体や環境に影響を及ぼすものではありませんが、漏れてはならない施設から放射性物質が漏れたという事実は、すべての原子力関係者が等しく肝に銘じなければならない問題であります。このうえは鋭意事故調査を進め、改めるべき点を解明し、それを早急に実施に移していく必要があります。

いうまでもなく、私達原子力開発の関係者は、こうした事故を契機とした原子力開発への批判を、厳粛に受け止めていくべきであります。「もんじゅ」の事故以来原子力関係者は事故原因の究明や原子力政策円卓会議の開催、各種審議会の公開など真剣に世論の動向を政策に取り入れようと努めてきました。しかしながら、原子力開発を今後どう進めるのかという視点に立ったとき、現在私達が直面している情勢は「混沌」という言葉がまさにふさわしいといえるでありましょう。

この二つの事故や巻町の住民投票などがマスメディアによってさかんに報道され、今日ほど原子力開発に対する市民の関心が高まったことは近年まれなことであります。核燃料リサイクルあるいはバックエンドの確立という開発の第二段階に入ろうとしている現在、今後のあり方について原点に立ち戻り、国民全体で考える良い機会かもしれません。いや、よい機会とするべきでありましょう。

この際原子力委員会、政府ならびに民間産業界はこれまでにも増して積極的に情報を公開して、国民の審判に耳を傾けるべきであります。同時になぜこのような原子力計画を進めようとしているのか、を率直に述べるべきでありましょう。

一方、原子力開発に対して批判的な方々は、原子力に代わる技術がなんであるか、について明らかにすることが必要だと思います。今後、世界における人口の増加と産業・社会の発展に伴って需要の増加が心配されているエネルギーの供給に対してどう対応するべきなのか、という問題についても明確な考えを出し議論して欲しいと思います。

私はそれに対する一つの有力な解決方法として、原子力があると考えておりますが、この技術が人類にとって安全なものであることは当然な条件です。

確かに原子力開発をめぐる情勢は「混沌」としておりますが、私たちに課せられている重要なことは目先の問題にとらわれず、時間がかかってもこの混沌の中から次に目指す道を探し出すこと、であります。今回の年次大会における討論がその第一歩となればこれ以上の名誉はありません。

最後になりましたが、改めて田原委員長をはじめ準備委員の方々、ご参集いただきました国内、海外の発表者の方々、会場の皆様に厚く感謝申し上げ、私の所信とさせていただきます。ご静聴ありがとうございました。

以　上

第三十回原産年次大会

原子力委員会委員長所感（案）

（はじめに）

本日、第三十回原産年次大会が、内外から多数の御参加を得て、かくも盛大に開催される運びとなりましたことをお喜び申し上げます。また、向坊会長、田原大会準備委員長をはじめ、大会の開催に尽力された方々の御苦労に敬意を表します。

（アスファルト固化処理施設火災爆発事故）

先月十一日に動燃事業団東海事業所のアスファルト固化処理施設において、火災爆発が起き、環境や健康に影響を与えるレベルではないものの屋外に放射性物質が放出されたことを大変重く受け止めております。

特に、一昨年の「もんじゅ」事故を真摯に受け止め、徹底した原因究明を行うとともに、「もんじゅ」の安全性総点検の着実な実施をしてきている矢先にこの事故が発生し、その後の情報伝達などの面で再び不適切な対応が繰り返され、地元をはじめ国民の皆様の不安・不信をさらに高めてしまったことは残念な限りです。

何よりもまず、徹底的な事故の原因究明と再発防止のための対策を講じるとともに、国民の皆様の信頼回復に向けて最大限の取組みを行っていかねばなりません。また、動燃

事業団が国民に信頼される機関となるよう、緊急時の危機管理体制を含めた組織・体制の抜本的改革を実施していく所存です。

（原子力・核燃料サイクルの必要性）

さて、二十一世紀を展望しますに、アジア地域を中心とする人口の増加や生活水準の向上は、今後のエネルギーの確保、食糧の確保等に深刻な影響を及ぼすことが懸念されます。特に、現代社会を支えているエネルギー基盤である化石エネルギーは、有限な資源であるばかりではなく、炭酸ガスによる地球温暖化や酸性雨等、地球環境に深刻な影響を与えかねないことが指摘されております。

これを踏まえ、エネルギーの確保については、省エネルギーや新エネルギーの開発に努めることはもちろんのこと、化石エネルギーに替わって大量のエネルギーを、安定して経済的に供給するため、今後、原子力を着実に進めることがますます重要となってくると考えています。

特に、資源に乏しい我が国においては、長期にわたるエネルギーの安定確保や放射性廃棄物による環境負荷の低減の観点から、原子力発電を長期に安定的に進めていく上で、核燃料サイクルを円滑に展開していくことが不可欠であります。これについては、本年、原子力委員会及び閣議において、改めてその必要性を確認するとともに、プルサーマルの推進、使用済燃料の管理、バックエンド対策など当面の課題について具体的考え方を示したところであります。

これらの施策の着実な展開に当たりましては、地元をはじめとする国民の皆様の理解が十分得られるよう、政府一体となって最大限努力していかなければならないと考えております。

（開かれた原子力への努力）

このため、国民とともにある原子力を目指しまして、昨年、原子力委員会において原子力政策円卓会議を開催するほか、関係省庁においてもシンポジウムや地域フォーラム等を開催するなど、様々な方々との対話を精力的に行ってきました。この過程におきまして、昨年九月に、情報公開の一層の推進と原子力政策への国民の参加の促進を柱とする原子力委員会決定を行い、会議の全面公開など、順次、具体的実施に移しているところであります。

今後とも、情報公開や国民との対話の一層の推進を図り原子力政策の透明性を高め、国民に開かれたものとなるよう努力を継続してまいります。

（核不拡散、原子力安全、国際協力）

また、原子力の開発利用に当たっては、厳に平和利用に限って進めるとともに、核拡散の防止を図っていくことが必要です。このため、我が国は、国内対応として、核不拡散条約に基づく保障措置を厳格に遵守するとともに、国際的にも、国際原子力機関や国際条約における各種検討へ積極的に参画しているところであります。

また、原子力の安全確保については、当該国における対策だけでなく、国際的な連携・協調の下に、維持・向上させていくことが重要であり、我が国としても、昨年発効した「原子力安全に関する条約」の円滑な実施に必要な措置を講じていくとともに、二国間・多国間協力等の枠組みを通じて、原子力安全に関して情報交換を行うなど、今後とも積極的に対応していく考えです。

（結言）

最後に、今回の事故を踏まえ、改めて安全確保と情報公開という基本原則を原子力関係者一同肝に命じ、原点にかえって再点検を実施することにより、信頼を回復することが重要であると考えております。皆様方におかれましても、一層の御支援、御尽力をお願い申し上げます。

本大会が、実り多き大会となることを祈念いたしまして、私の所感とさせていただきます。

平成九年四月九日

国務大臣科学技術庁長官
原子力委員会委員長　　　近岡理一郎

JAIF Chairman's Address to the 30th JAIF Annual Conference

Dr. Takashi Mukaibo
Chairman
Japan Atomic Industrial Forum, Inc.
April 9, 1997

Mr. Chairman, ladies and gentlemen:

It is my great pleasure to address you on behalf of the Japan Atomic Industrial Forum, at this opening of its 30th Annual Conference.

First, I would like to express my sincere appreciation for the fact that so many people, from both within and outside Japan, could gather here today.

As you know, this is the 30th of these Annual Conferences. The first was in February, 1968, where I — then a professor at the University of Tokyo — spoke on the safety of nuclear facilities. At that time, light water reactors were being built one after another in Japan, and a program to localize nuclear power industry based on the technologies introduced from abroad was underway. I remember as if it were yesterday, standing before the audience, feeling almost physically excited by the fact that private industry was devoting itself to the commercial use of nuclear power. According to our records, 600 people attended that first conference. Today, there are more than 1,400 people here, from around the world and from an array of fields and disciplines. Seeing this, I cannot but feel anew the tremendous progress nuclear power has made in this country.

Since the very beginning, these JAIF annual conferences have aimed at in-depth, wide-ranging explorations of nuclear-development issues, not limited to matters of technology or energy supply, but including political and social viewpoints. In recent years, we have tried to bring the general public more into our discussions. Marking this 30th year at a time when the public's attitude toward nuclear power is quite severe, we asked Mr. Soichiro Tahara, a noted social and political commentator, to serve as the chairman of the Program Committee. Other members of the Committee include a critic of nuclear power and neutral journalists. In his presentation later, Chairman Tahara will say more, I think, about the purpose of the conference and the program -- which promises to be the best ever, thanks primarily to the earnest and tireless manner in which the committee went about its task.

In Japan today, as I just indicated, the general public has a critical view of nuclear development, and there is no doubt that the sodium leakage at the fast-breeder reactor Monju in December 1995, and the accident at the bituminization facility for low-level radioactive waste at the Power Reactor and Nuclear Fuel Development Corporation's Tokai Facility on March 11 of this year are parts of the reason. I am very sorry that these failures occurred while the nation was making great strides in its nuclear fuel recycling program — a long-sought pillar of the nuclear effort — thereby damaging the nation's confidence in nuclear development. Although the amount of radioactivity released from the bituminization facility was too small to have any effect either on people or the environment, all who are involved in nuclear power development must keep in mind that such an event itself should not have happened at all. Now that it has, it is necessary to thoroughly investigate the whys and hows, determine what should be corrected, and implement the changes as quickly as possible.

It goes without saying that we, the nuclear community, must accept the criticism arising from these accidents. Since the Monju incident, those concerned have been making the most sincere efforts to reflect public opinion in nuclear policy — through their investigations of that accident, by making committee meetings open to the public, through a series of round-table conferences on nuclear policy, and more. When it comes to the question of the future course for nuclear development, however, the current situation surrounding nuclear power can be described in one word: "confused."

The Monju and Tokai accidents and the referendum in the town of Maki have been covered heavily in the mass media, creating a level of interest in nuclear issues rarely seen. Now that the second phase of nuclear development, fuel recycling, the back end, is getting underway, this may be a good opportunity—and we should not miss it—for the entire nation to look back to the starting point, realize why we undertook nuclear development in the first place, and decide what we want the future to be.

The Atomic Energy Commission of Japan, the national government, and private business should promote the disclosure of information more aggressively than ever, and listen to the nation's response. They should also speak out frankly on why they pursue the nuclear program.

At the same time, those who are critical of nuclear development should be required to show what technologies can replace nuclear power. I want them to express clear views on how to cope with increasing energy demand as the world's population grows and nations become more industrially and socially advanced.

I think nuclear power can be one of the most efficient solutions to this problem—

depending naturally on the safety of the technology.

It is true, as I said, that the current situation surrounding nuclear power is confused. What we must do is find our way out of the confusion, taking whatever time that requires, and not be swayed too much by the problems of the moment. It would be an honor, indeed, if what is discussed at this Annual Conference could be could be a step in that direction.

In closing, I express my deep gratitude once again to Chairman Tahara and the members of the Program Committee, to all of our speakers, from Japan and from abroad, and to you, the audience.

Thank you.

世界の安全保障の展望、および２１世紀における核兵器の役割

元米国国防長官、元世界銀行総裁
R. マクナマラ

２１世紀には２０世紀のような大量殺戮を繰り返すことがあってはならない。今こそ、この悲劇を防ぐための行動を開始する時が来た。そのためには三つの具体的なステップが必要である。

1. 国家間の紛争のリスクを低減するため、集団安全保障のシステムを確立すべきである。

2. 集団安全保障のシステムは、大国間の戦争のリスクを制限することを特に重視すべきである。

3. 集団安全保障が効力を失った場合に、国家破壊のリスクをなくすため、実行可能な限り、核のない世界に戻るべきである。

人類は誤りを犯しやすい。人類の誤りの犯しやすさと核兵器との無限の組み合わせには、非常に高い潜在的破局のリスクが伴うのである。

A Vision of Global Security, and the Role of Nuclear Weapons
in the Twenty-first Century
by Robert S. McNamara

We must not permit the 21st Century to repeat the slaughter of the 20th. The time to initiate action to prevent that tragedy is now. Three specific steps are required:

1. To reduce the risk of conflict within and among states we should establish a system of Collective Security.

2. The system of Collective Security should place particular emphasis on limiting the risk of war between or among Great Powers.

3. To eliminate the risk of destruction of nations, in the event Collective Security breaks down, we should return, insofar as practical, to a non-nuclear world.

Human beings are fallible. The indefinite combination of human fallibility and nuclear weapons carries a very high risk of a potential catastrophe.

1/15/97 DRAFT
Tokyo
4/9/97

A Vision of Global Security, and the Role of Nuclear Weapons
in the Twenty-first Century
by Robert S. McNamara

I have been asked to speak for 30 minutes on my vision of global security and the role of nuclear weapons in the 21st century and then to take questions. I will be happy to do so. For me the question and answer period is often the most interesting part of the meeting and I suspect it may be for you as well.

I want to begin my remarks by telling you of my earliest memory as a child. It is of a city exploding with joy. The city was San Francisco. The date was November 11, 1918 -- Armistice Day. I was two years old. The city was celebrating not only the end of World War I, but the belief, held so strongly by President Wilson, and by many other Americans, that the United States and its allies had won the war to end all wars.

They were wrong, of course. The Twentieth Century was on its way to becoming the bloodiest, by far, in all of human history: during it, 160 million people will have been killed in conflicts across the globe.

So, my thesis, this afternoon is that we must not permit the 21st Century to repeat the slaughter of the 20th. The time to initiate action to prevent that tragedy is now. I believe three specific steps are required:

1. To reduce the risk of conflict within and among states we should establish a system of Collective Security.
2. The system of Collective Security should place particular emphasis on limiting the risk of war between or among Great Powers.

3. To eliminate the risk of destruction of nations, in the event Collective Security breaks down, we should return, insofar as practical, to a non-nuclear world.

First, my approach to Collective Security.

Although clear evidence has existed since the mid-1980s that the Cold War was ending, nations throughout the world have been very slow to revise their foreign and defense policies, in part because they do not see clearly what lies ahead.

As the Iraqi invasion of Kuwait, the civil war in the former Yugoslavia, and the turmoil in Northern Iraq, Somalia, Haiti, Sudan, Rwanda and Burundi make clear, the world of the future will not be without conflict, conflict between disparate groups within nations and conflict extending across national borders. Racial, religious, and ethnic tensions will remain. Nationalism will be a powerful force across the globe. Political revolutions will erupt as societies advance. Historic disputes over political boundaries will endure. And economic disparities among nations will increase as technology and education spread unevenly around the world. The underlying causes of Third World conflict that existed long before the Cold War began remain now that it has ended. They will be compounded by potential strife among states of the former Soviet Union and by continuing tensions in the Middle East. It is just such tensions that in the past forty-five years have contributed to 125 wars causing 40 million deaths in the Third World.

So, in these respects, the world of the future will not be different from the world of the past -- conflicts within nations and conflicts among nations will not disappear. But relations between nations will change dramatically. In the post-war years, the United States had the power -- and to a considerable degree we exercised that power -- to shape the world as we chose. In the next century, that will not be possible.

Japan is destined to play a larger and larger role on the world scene, exercising greater economic and political power and, one hopes, assuming greater economic and political responsibility. The same can be said of Western Europe, following its major step toward economic integration. Greater political unity is bound to follow (despite opposition to the Maastricht Treaty), and that will strengthen Europe's power in world politics.

And by the middle of the next century, several of the countries of what in the past we have termed the Third World will have grown so dramatically in population and economic power as to become major forces in international relations. India is likely to have a population of 1.6 billion; Nigeria, 400 million; Brazil, 300 million. And if China achieves its ambitious economic goals for the year 2000, and then maintains satisfactory but not spectacular growth rates for the next fifty years, its 1.6 billion people will have the income of Western Europeans in the 1960's. It will indeed be a power to be reckoned with: economically, politically and militarily. We in the US have not even begun to relate properly to the China of the 21st Century.

The figures I have cited are highly speculative, of course, but I point to them to emphasize the magnitude of the changes that lie ahead.

While remaining the world's strongest nation, the United States will live in a multipolar world, and its foreign policy and defense programs must be adjusted to this emerging reality. In such a world, need clearly exists for developing new relationships both among the Great Powers -- and between the Great Powers and other nations.

Many political theorists, in particular, those classified as "realists," predict a return to traditional power politics. They argue that the disappearance of ideological competition between East and West will trigger a reversion to traditional relationships based on territorial and economic imperatives: they say that the United States, Russia, Western Europe, China, Japan, and perhaps India will seek to assert themselves in their own regions while still competing for dominance in other areas of the world where conditions are fluid. This view has been expressed, for example, by Harvard Professor Michael Sandel. Sandel has written: "The end of the Cold War does not mean an end of global competition between the Superpowers. Once the ideological dimension fades, what you are left with is not peace and harmony, but old-fashioned global politics based on dominant powers competing for influence and pursuing their internal interests."

Henry Kissinger, also a member of the realist school, has expressed a similar conclusion.

Kissinger's and Sandel's conceptions of relations among nations in the post-Cold War world are, of course, historically well founded, but I would argue that they are inconsistent with our increasingly interdependent world. No nation, not even the United States, can stand alone in a world in which nations are inextricably entwined with one another economically, environmentally, and with regard to security. I believe, therefore, that the for the future, the United Nations charter offers a far more appropriate framework for international relations than does the doctrine of power politics.

Above all else, as I suggested, emphasis should be placed on avoiding conflict among the Great Powers.

The two most important geo-political events of the past half-century were the reconciliation between France and Germany after centuries of enmity, and the establishment of peaceful relations between Japan and the US after one of the bloodiest and most ferocious conflicts in the modern era. It is inconceivable today that either Germany or Japan would engage in war with any of the Great Powers of the Western World. Can we not move to integrate both Russia and China into the family of nations in ways that make war between them and other Great Powers just as unlikely?

In December 1995, one of the brightest and most personable Japanese I have ever met -- Mr. Kenzaburo Ohe, the Nobel Laureate in literature, visited me during the Christmas holidays at my vacation home in Aspen, Colorado to record a conversation for Japanese television. I wish to repeat for you a few paragraphs of our conversation.

I said: "Mr. Ohe I am indebted to you for coming all the way from Tokyo to meet with me. that's a long, long, journey and I'm very, very grateful to you. I'm particularly grateful for your interest in discussing what, to me, is really the most important subject in the world today. How to prevent these terrible wars that both of our nations have suffered from.

"This century will go down as the bloodiest century in all of human history. I know it is your desire and my desire that the twenty-first century not be a repetition of that. The question is, what can your nation do and what can my nation do to prevent that? I hope that's what we can talk about."

Mr. Ohe replied: "Mr. McNamara, because Japan was deeply involved in the East Asian and Pacific strategies like the United States, I believe much of the

Cold War structure still remains in my country. Because of this, it is our task to make efforts for peaceful and hopeful 21st century efforts to seek a new way for mutual existence without shedding any blood, and seek the way to participate in this new global relationship.

"I think you are shrewdly aware of what Japan did during the Cold War days. Do you think Japanese can participate in forming a concept for the new mutual existence after the cold war and in realizing this concept?

I said: "That is, of course, a question that really the Japanese should answer. But let me give you my answer. It is more a hope than a belief. I hope that Japan will participate in developing the international order for the twenty-first century. And I hope that Japan's participation will assist in moving that order toward a world of peace.

"Now, I know Japan has a conflict of interests here. The Japanese do not wish in any way to see their country revert to its pre-World War II militarism. I admire the Japanese people for their wish to avoid militarism.

"On the other hand, I think that, if I may be personal, I think that Japan has carried that feeling too far in this post-cold War world, because Japan removed itself from global politics. It hasn't been a member of the Security Council. I think it should be. It hasn't played a major role in United Nations peacekeeping affairs. I think it should. It hasn't really played a role, for example, in pushing China, Russia, the US, France and Britain to give up nuclear weapons. I think it should. It hasn't played a role in ensuring that China and Russia, in particular, are integrated into the family of nations as closely as US and Japan and France and Germany.

"No member of our audience today would ever believe that the US and Japan would fight a war again. Nor would they believe that France and Germany would fight a war again. Japan must help the US work with China and Russia to ensure that we will never fight a war again.

So I hope Japan will play a much, much greater role in geopolitics in the twenty-first century than it has in the past half century."

I return now to my discussion of Collective Security.

Before nations can respond in an optimum manner to the end of the Cold War, they need a vision -- a conceptual framework -- of a world that would not be dominated by the East-West rivalry that shaped foreign and defense policies across the globe for more than forty years. In that new world, I believe security relationships among nations should be directed toward three goals: They should

1. Provide all states guarantees against external aggression -- frontiers should not be changed by force.
2. Codify the rights of minorities and ethnic groups within states -- the Kurds in Iran, Iraq, and Turkey, for instance -- and provide them a means to redress their grievances without resort to violence.
3. Establish a mechanism for resolving regional conflicts and conflicts within nations without unilateral action by the Great Powers.

In sum, I believe we should strive to create a world in which relations among nations would be based on the rule of law, a world in which national security would be supported by a system of collective security. The conflict prevention, conflict resolution, and peace-keeping functions necessary to accomplish these objectives would be performed by multilateral institutions, a reorganized and strengthened United Nations together with new and expanded regional organizations.

That is my vision of the post-Cold War world.

Such a vision is easier to articulate than to achieve. The goal is clear; but how to get there is not. And I have no magic formula, no simple road map to success. I do know that such a vision will not be achieved in a month, a year, or even a decade. It will be achieved, if at all, slowly and through small steps, by leaders of dedication and persistence. So I urge that we move now in that direction.

Fortunately, we have time to proceed step by step. The risk of large-scale military operations between or among Great Powers is probably less today than at any time since the end of World War II. Although, we cannot be certain they will never again take place, what we can do is to insure that if the system of Collective Security breaks down and war between Great Powers occurs, it will not be fought with nuclear weapons and, therefore, will not lead to total destruction of nations.

We in the US, you in Japan, and all other inhabitants of our globe continue to live with the risk of nuclear destruction. Today, the United State's war plans provide for contingent use of nuclear weapons just as they did when I was Secretary of Defense in the 1960s. But I do not believe that the average American or Japanese recognizes this fact. No doubt, he or she was surprised and pleased by the announcement by Presidents Bush and Yeltsin in June 1992 that they had agreed to reduce dramatically U.S. and Russian nuclear weapon stockpiles. Today, there are 40,000-50,000 nuclear warheads in the world, with a total destructive power more than 1 million times greater than that of the bomb that flattened Hiroshima. Assuming the reductions called for by the START 1 Treaty are achieved, the total weapons inventory will be reduced to approximately 20,000. Bush and Yeltsin agreed to further reductions that would leave the five declared nuclear powers (the United States, Russia, France, the United Kingdom and China) with a total of about 10,000 warheads in 2003. It was a highly desirable move, but even if the agreement is ratified by both the U.S. Senate and the Russian Parliament -- and that is not at all certain -- the risk of destruction of societies across the globe, while somewhat reduced, will be far from eliminated. I doubt that a survivor -- if there was one -- could perceive much difference between a world in which 10,000 nuclear warheads had been exploded and one subject to attack by 40,000. So the question is can we not go further? Surely the answer must be *yes.*

The end of the Cold War, along with the growing understanding of the lack of utility of nuclear weapons and of the high risk associated with their continued existence, points to both the opportunity and the urgency with which the nuclear powers should reexamine their long-term nuclear force objectives. We should begin with a broad public debate over alternative nuclear strategies. I believe such a debate would support the conclusion that we should move back to a non-nuclear world.

In support of my position, I will make three points:

1. The experience of the Cuban Missile Crisis in 1962 -- and, in particular, what has been learned about it recently -- makes clear that so long as we and other Great Powers possess large inventories of nuclear weapons, we will face the risk of their use and the destruction of our nation.
2. That risk is no longer -- if it ever was -- justifiable on military grounds.
3. In recent years, there has been a dramatic change in the thinking of leading Western security experts -- both military and civilian -- regarding the military utility of nuclear weapons. More and more of them -- although certainly not yet a majority -- are expressing views similar to those I have stated.

First, the Cuban Missile Crisis:

It is now widely recognized that the actions of the Soviet Union, Cuba, and the United States in October 1962 brought the three nations to the verge of war. But what was not known then, and is not widely understood today, was how close the world came to the brink of nuclear disaster. Just six months ago, the Kennedy Library released heretofore highly classified tapes which provided new insight into the near catastrophe. Neither the Soviet Union, nor Cuba, nor the United States intended, by its actions, to create such risks.

You may recall that the crisis began when the Soviets moved nuclear missiles and bombers to Cuba -- secretly and with the clear intent to deceive -- in the summer and early fall of 1962. The missiles and bombers were to be targeted against cities along America's East Coast, putting 90 million people at risk. Photographs taken by a U-2 reconnaissance aircraft on Sunday, October 14, 1962 brought the deployments to President Kennedy's attention. He and his military and civilian security advisers believed that the Soviets' action posed a threat to the West. Kennedy therefore authorized a naval quarantine of Cuba to be effective Wednesday, October 24. Preparations also began for air strikes and an amphibious invasion. The contingency plans called for a "first-day" air attack of 1080 sorties, a huge attack. An invasion force totalling 180,000 troops was assembled in Southeastern US ports. The crisis came to a head on Saturday, October 27 and Sunday, October 28. Had Khrushchev not publicly announced on Sunday that he was removing the missiles, I believe that on Monday a majority of Kennedy's military and civilian advisers would have recommended launching the attacks.

To understand what caused the crisis -- and how to avoid similar ones in the future -- high-ranking Soviet, Cuban, and American participants in the decisions relating to it met in a series of conferences beginning in 1987 and extending over a period of five years. A meeting chaired by Fidel Castro in Havana, Cuba, in January 1992 was the fifth and last.

By the conclusion of the third meeting in Moscow in January 1989, it had become clear that the decisions of each of the three nations, before and during the crisis, had been distorted by misinformation, miscalculation, and misjudgment. I shall cite only four of many examples:

> Before Soviet missiles were introduced into Cuba in the summer of 1962, the Soviet Union and Cuba believed the United States intended to invade the island in order to overthrow Castro and remove his government. We had no such intention.
>
> The United States believed the Soviets would never move nuclear warheads outside the Soviet Union-- they never had -- but in fact they did. In Moscow, in 1989, we learned that by October 1962, although the CIA at the time was reporting no nuclear weapons on the island, Soviet nuclear warheads had, indeed, been delivered to Cuba, and, as I have said, they were to be targeted on U.S. cities.
>
> The Soviets believed that nuclear weapons could be introduced into Cuba secretly , without detection, and that the US would not respond when their presence was disclosed. There, too, they were in error.
>
> and Finally, those who were prepared to urge President Kennedy to destroy the missiles by a US air attack which, in all likelihood, would have been followed by an amphibious invasion, were almost certainly mistaken in their belief that the Soviets would not respond militarily. At the time, the CIA reported 10,000 Soviet troops in Cuba. At the Moscow conference, participants learned there were in fact 43,000 Soviet troops on the island, along with 270,000 well-armed Cuban troops. Both forces, in the words of their commanders, were determined to "fight to the death." The Cuban officials estimated they would have suffered 100,000 casualties. The Soviets -- including long-time Foreign Minister Andrei A. Gromyko and former Ambassador to the US Anatoly Dobrynin -- expressed utter disbelief that we would have thought that, in the face of such a catastrophic defeat, they would not have responded militarily somewhere in the world. Very probably, the result would have been uncontrollable escalation.

In 1962, during the crisis, some of us -- particularly President Kennedy and I -- believed the United States faced great danger. The Moscow meeting confirmed that judgment. But during the Havana conference, we learned that both of us -- and certainly others -- had seriously underestimated those dangers. While in Havana, we were told by the former Warsaw Pact Chief of Staff, General Anatoly Gribkov, that, in 1962, Soviet forces in Cuba possessed not only nuclear warheads for the intermediate-range missiles targeted on US cities, but nuclear bombs and tactical nuclear warheads as well. The tactical warheads were to be used against US invasion forces. At the time, as I mentioned, the CIA was reporting no warheads on the island.

In November 1992 -- thirty years after the event -- we learned more. An article appeared in the Russian press which stated that, at the height of the Missile Crisis, Soviet forces on Cuba possessed a total of 162 nuclear warheads, including at least 90 tactical warheads. Moreover, it was reported that, on October 26, 1962 -- a moment of great tension -- warheads were moved from their storage sites to positions closer to their delivery vehicles in anticipation of a US invasion.[1] The next day, Soviet Defense Minister Malinovsky received a cable from the Soviet commander in Cuba, informing him of this action. Malinovsky sent it to Khrushchev. Khrushchev returned it to Malinovsky with "Approved" scrawled across the document. Clearly, there was a high risk that, in the face of a US attack -- which, as I have said, many in the US government, military and civilian alike, were prepared to recommend to President Kennedy -- the Soviet forces in Cuba would have decided to use their nuclear weapons rather than lose them.

We need not speculate about what would have happened in that event. We can predict the results with certainty.

Although a US invasion force would not have been equipped with tactical nuclear warheads -- the President and I had specifically prohibited that -- no one should believe that had American troops been attacked with nuclear weapons, the US would have refrained from a nuclear response. And where would it have ended? In utter disaster, not only for the US, Cuba and the Soviet Union, but for nations across the world, including Japan, that would have been affected by the nuclear fall out.

The point I wish to emphasize is this: human beings are fallible. We all make mistakes. In our daily lives, mistakes are costly, but we try to learn from them. In conventional war, they cost lives, sometimes thousands of lives. But if mistakes were to affect decisions relating to the use of nuclear forces, there would be no learning period. They would result in the destruction of nations. I believe, therefore, it can be predicted with confidence that the indefinite combination of human fallibility and nuclear weapons carries a very high risk of a potential catastrophe.

Is there a military justification for continuing to accept that risk? The answer is no.

The military utility of nuclear weapons is limited to deterring one's opponent from their use. Therefore, if our opponent has no nuclear weapons, there is no need for us to possess them.

Partly because of the increased understanding of how close we came to disaster during the Missile Crisis, but also because of a growing recognition of the lack of military utility of the weapons, there has been a revolutionary change in thinking about the role of nuclear forces. Much of this change has occurred in the past five years. Many military leaders are now prepared to go far beyond the Bush-Yeltsin agreement. Some go so far as to state, as I have, that the long-term objective should be a return, insofar as practical, to a non-nuclear world.

That is, however, a very controversial proposition. A majority of Western security experts -- both military and civilian -- continue to believe the threat of the use of nuclear weapons prevents war. Zbigniew Brzezinski, President Carter's National Security Adviser, has argued that a plan for eliminating nuclear weapons "is a plan for making the world safe for conventional warfare. I am therefore not enthusiastic about it." A report of an advisory committee, appointed by former Defense Secretary Richard Cheney and chaired by former Air Force Secretary Thomas Reed, made essentially the same point. Clearly the current Administration supports that position However, even if one accepts that argument, it must be recognized that the deterrent to conventional force aggression carries a very high long-term cost: the risk of a nuclear exchange.

It is that risk -- which to me is unacceptable -- that is leading prominent security experts to change their views. I doubt that the public is aware of these changes.

Today given the widely divergent views of security experts, but with the recognition by all that initiation of the use of nuclear weapons against a nuclear equipped opponent would lead to disaster -- should we not begin immediately to debate the merits of alternative long-term objectives for the five declared nuclear powers?

We could choose from three options:

1. A continuation of the present strategy of "extended deterrence," the strategy reconfirmed last year by the Clinton Administration.[8] This would mean limiting the US and Russia to approximately 3,500 strategic warheads each, the figure agreed upon by Presidents Bush and Yelstin.

   or

2. A minimum deterrent force with the two major nuclear powers retaining no more than 1,000-2,000 warheads each.

   or

3. As I strongly advocate, a return, by all five nuclear powers, insofar as practicable, to a non-nuclear world[1]

It was to contribute to that debate, that in late 1994 Prime Minister Keating of Australia appointed an international commission to develop proposals for "a program to achieve a world totally free of nuclear weapons." The Commission members included, among others: Michel Rocard, the former prime minister of

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[1] "Insofar as practicable" refers to the necessity of maintaining protection against "breakout" in the states which previously possessed nuclear weapons or acquisition of such weapons by rogue states or terrorists. The eliminatio of nuclear weapons could be accomplished in a series of steps.

France; Joseph Rotblat, the 1995 Nobel Laureate and one of the designers of the original nuclear bomb; Field Marshal Lord Carver, former Chief of the British Defense Staff; General Lee Butler, former commander of the US Strategic Air Command; and myself. The Commission's recommendations -- reported in what has become known as the Canberra Commission Report -- were unanimous. They were presented without any qualification or even the slightest note of dissent. They urged the five Declared Nuclear Powers -- China, Russia, Britain, France and the United States -- to state their unequivocal political commitment to the elimination of nuclear weapons and that they accompany such a commitment by three immediate steps pointed toward fulfilling it:

1. The removal of all nuclear weapons from alert status.
2. The separation of all nuclear warheads from their launch vehicles.
3. A declaration of No First Use of nuclear weapons against nuclear states, and No Use against non-nuclear nations. The US has never been willing to make such a pledge.

On December 5 of last year, nineteen senior retired US military officers and 42 senior admirals and generals from other nations across the world joined in supporting the recommendation for complete elimination of nuclear weapons.

Years will pass before these recommendations are fully implemented. But we are beginning to break out of the mindset that has guided the strategy of the nuclear powers for over four decades. More and more political and military leaders are coming to understand two fundamental truths: we can indeed "put the genie back in the bottle," and if we do not, there is substantial risk that the 21st Century will witness a nuclear holocaust.

In sum, then, with the end of the Cold War, if we act to establish a system of Collective Security, if we place particular emphasis on avoiding war among the Great Powers, and if we take steps to return to a non-nuclear world, the twenty-first century, while certainly not a century of tranquillity, need not witness the killing, by war, of another 160 million people. Surely that must be not only our hope, not only our dream, but our steadfast objective. I know that some of you -- perhaps many of you -- may consider such a statement so naive, so simplistic, and so idealistic as to be quixotic. But as human beings, citizens of a great nation with the power to influence events in the world, can we be at peace with ourselves if we strive for less? I think not. I hope you will agree.

２１世紀をどう生きるか

秩父小野田(株)取締役相談役
経済同友会幹事
諸　井　　虔

Ｉ．２１世紀人類の課題

１．地域紛争・民族紛争の解決
２．人口爆発の抑制
３．貧困退治――途上国の経済発展
４．環境破壊、資源、エネルギー、食糧不足の解決

II．日本の役割

We in the 21st Century

Ken Moroi
Counselor & Director, Chichibu Onoda Cement Corp.
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I. Human Tasks in the 21st Century

1. Settlement of Regional and Racial Conflicts
2. Control of the Population Explosion
3. Elimination of Poverty — Economic Growth in Developing Countries
4. Solutions to the Problems of Environmental Pollution and Shortages of Natural Resources, Energy, and Food

II. Role of Japan for the 21st Century

創られた恐怖：大きな恐れ．．．しかし小さなリスク
―最新技術の危険を誇張することがわれわれの健康とより高い生活水準の追求にとって危険な理由―

科学と健康に関する全米会議会長
エリザベス M. フェラン

私たちは膨大な量の科学技術が支配する時代に生きている。私たちが持つ技術的ノウハウを使えば、健康増進のための、豊富で安全で手頃な値段の食料品、生命を救う医薬品、効率的でクリーン、手頃な価格で安全なエネルギー、それにレジャーや自由をもたらし、生活を快適にしてくれる膨大な種類の消費者製品を生産することができる。しかし、多くの消費者それにマスメディアは、高度な技術の応用がもたらしてくれる羨むべき生活水準を喜ぶのとは違って、これらの技術を恐れ、殺虫剤、バイオテクノロジー、原子力、医薬品に対して、先天性欠陥やその他の形態の疾病を引き起こすものと非難するようになった。

特定の技術への恐れが増大すれば、たとえその恐怖が科学的に根拠のないものであっても、その技術を拒否するに至ることは避けられない。皮肉なことに、時には拒否すること自体から新たな健康リスクが現れる。しかし、健康やいわゆる幸福な生活に対する環境上の脅威に関する公衆の議論は、感情的な非難に走ることが多く、科学や理性は対話から省かれ、リスクとベネフィットの関係はあいまいなものになる。

一般消費者が毎日聞かされる様々なリスクを正しく定量的に理解するのを支援するために主導的役割を果たすこと、さらに科学的に根拠のないリスクをむやみに議論し続ければ、かえって本当の健康リスクが生じるということを強調することは、全世界の科学界に課せられた義務である。こうした本当の健康リスクとは、次のようなものである。

ａ）微々たるリスクあるいは仮想リスクにとらわれ、健康優先度を逆さまにして規制方針を策定してしまい、長寿や健康を脅かす真の公衆衛生面の危険と対決する時間も資金も残しておかないこと。

ｂ）ありもしないリスクを回避しようとして、その結果、それに代わる食品、エネルギー、および医薬品の生産方式を受け入れ、かえって大きな健康リスクを招いてしまう。

歴史的に見て、技術、産業のもたらす富、それに健康は極めてはっきりした相関性がある。技術、富および健康はワンセットになっている。根拠のない恐怖から技術を拒む社会は、将来の健康と生活水準を重大な危険に陥れている。環境や技術面のリスクを評価し、間接的なリスクや仮想リスクから真のリスクを選別する際には、政治や感情、レトリックではなく科学が支配しなければならない。

Toxic Terror: Big Fears but Little Risks

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presentation

JAIF Annual Conference
Tokyo , Japan

April 9, 1997

Thank you very much, ladies and gentlemen, for the opportunity to address this most distinguished forum.

Today I will explore with you the reasons why exaggerated fear of the dangers of modern technology is, in my opinion, hazardous to our health and to our pursuit of a higher standard of living.

Before even I begin my comments, please let me point out what is clearly obvious: I am an American, so I can legitimately report to you only on experiences, events, facts, and myths about health in the United States. But I do hope you will find many, if not all, of my comments relevant to your experiences with consumer health concerns here in Japan.

We live in an age dominated by a dizzying array of scientifically based technologies. Our technological know-how allows us to produce a wholesome, abundant, safe, and affordable food supply; life-saving pharmaceuticals; efficient, clean, affordable, and safe sources of energy; and a staggering variety of consumer products that give us more leisure and more freedom and that generally make our lives easier.

But instead of rejoicing over the enviable standard of living our technological expertise affords us, many of today's consumers—and many of the people in the media who report to those consumers—have come to fear these life-enhancing technologies. They blame pesticides, biotechnology, nuclear energy, trace levels of environmental chemicals like asbestos—even trace levels of estrogenlike compounds in the environment—for cancer, birth defects, and a whole host of human illnesses and dysfunctions.

A growing fear of specific technologies—*even though there is no scientific basis for that fear*—will inevitably lead to rejection of those technologies or cause a severe form of social and economic disruption aimed at purging allegedly harmful chemicals from air, water, and food. And, ironically, sometimes that very rejection will itself cause *new* health risks to appear. Also, because most public discussions of health and these alleged environmental threats to our well-being become emotionally charged, science and reason are frequently missing from the dialogue. As a result, the risk-to-benefit ratio is obscured.

It is my goal today to encourage a return of science and reason to our public evaluations of environmental health issues. It is also my goal to challenge the popular wisdom that provides the framework for what I call "toxic terror"—a state of fear of the products of technology. I will begin by examining five basic premises—premises I will show to be myths—that have caused many consumers to suffer from "toxic terror."

The first premise is that there is an epidemic of cancer today—of cancer caused by the modern technology introduced in the second half of this century.

The second is that life in a natural state is healthier and better, and that synthetic and man-made products are inherently hazardous to our health.

The third is that it is always better to be safe them sorry; that is, that the so-called precautionary principle should dominate our decisions: If there is even a hint of a problem, the technology or chemical exposure in question should be eliminated.

The fourth is that a mouse is a little man: that animal experiments validly and accurately predict human cancer risk; and that if something causes cancer in the laboratory, it should be assumed to cause cancer in humans, no matter how high the laboratory exposures and how minuscule the human exposures.

The fifth is that if high-dose exposures or long-term exposures to a substance are hazardous, then it must be assumed that exposures *de minimis*—trace-level exposures—to the same substance are also harmful and thus cannot be tolerated. This myth clearly rejects a basic principle of toxicology: the principle that "the dose makes the poison."

After I have looked at those five myths, I will focus on five specific examples of "toxic terrorism": cases in which consumers' fears about technology—and the resultant demands for regulation—were not grounded in science.

Those five examples will be:

A. DDT, and the concern about it that launched the modern-day environmental movement;
B. fears about pesticides, and particularly the fears about a chemical called Alar that caused a national panic in the United States in 1989;
C. asbestos, and how the fear of it actually closed down the largest school system in the United States;
D. nuclear power;
E. bioengineered food and the efforts made by environmentalists to block its advancement and marketing.

I will close by explaining some of the causes of toxic terrorism—and proposing a solution.

1. The So-Called Cancer Epidemic

The media—and many advocacy groups—would have the American public believe that the U.S. is in the midst of a cancer "epidemic." These groups perpetuate the myth that there has been a sudden surge in new cases of cancer and cancer deaths and that environmental agents are the cause. But a careful review of the facts indicates that:

- It is rates—and, in particular, age-adjusted rates—of cancer cases, rather than simple numbers of cases, that are important in assessing trends. Obviously, there are more cancer cases—and deaths—in 1997 than there were in 1900—but the U.S. population has more than doubled in that time. And the age distribution of the population has shifted over time, as well: Our population today includes many more older people. Clearly, given that cancer is a condition more likely to occur in older people, and other things being equal, the higher the proportion of elderly people in the population, the higher the cancer rate will be. Thus, it is necessary to age-adjust data to make comparisons between one era and another meaningful. Furthermore, given that "cancer" is a name for many different diseases with many different risk factors, we must specify just which type of cancer we are monitoring.

- With a few exceptions—primarily lung cancer and AIDS-related cancers—there has been little overall increase over the past 40 years in either the number of new cases of cancer reported or in the number of cancer deaths.

- The number of deaths caused by many forms of cancer has actually decreased. This includes deaths from Hodgkin's disease and from cancers of the cervix, uterus, stomach, rectum, testis, bladder, and thyroid.

- Modern screening methods—mammography and the PSA test for prostate cancer, for example—create the *appearance* of a sudden increase in new cancer cases. There is no correspondingly large increase in mortality from these forms of cancer.

- Most preventable cancers are related to known lifestyle factors, not to environmental chemicals. Among the proven causes of cancer are tobacco use; a diet low in fruits and vegetables; alcohol, particularly in conjunction with tobacco use; and overexposure to sunlight.

- The bottom line is that there is no cancer epidemic, and chemicals in our food and our environment do not have a significant impact on overall cancer risk in the United States.

2. "Natural" Is Better

An underlying theme, almost on a philosophical or a religious level, in the environmental literature is that technology is inherently life-threatening; that chemicals, by definition, are dangerous; and that the health of Americans would be far better if we lived our lives more "naturally"—free from the deleterious brews spewing from the test tubes of irresponsible "alchemists." "Nature" is seen as a benign force; human power is perceived as evil. Naturalness is equated with goodness.

Obviously, this natural-versus-synthetic dichotomy is both misleading and absurd. Epidemics of disease are natural. So are earthquakes, volcanic eruptions, floods and droughts. So are airborne pollens from a wide variety of allergenic plants. Beyond that, many natural substances, including some 100-percent natural foods, contain toxins (otherwise known as poisons) as well as chemicals that cause cancer in laboratory animals. Each year we at the American Council on Science and Health publish a dinner menu featuring a typical American holiday meal. We have our toxicologists analyze every one of the natural foods on that menu—and those toxicologists find a toxin or an animal carcinogen in every course. Carrots contain carotatoxin, a fairly potent nerve poison. Radishes contain goitrogens—chemicals that promote goiter by interfering with the body's use of iodine. Shrimp are a rich source of several minerals, including arsenic. Pepper and nutmeg contain myristicin, a powerful hallucinogen.

Furthermore, a whole array of natural substances have been shown to cause cancer in animals—and, in some cases, in humans. Safrole, a component of the natural sassafras plant and present in oil of sassafras, causes cancer in some animals. Aflatoxin molds—which can grow on a variety of natural substances, including peanuts, rice, corn, and soybeans—increase the risk of cancer in a wide variety of laboratory animals. There is also much circumstantial evidence that exposure to aflatoxins may play a role in human liver cancer. Bracken fern is a powerful cancer-causing agent. And all of these toxins, all of these animal carcinogens, are part of nature.

3. You Can't Be Too Safe

Those who foment "toxic terror" and point to the allegedly evil elements of technology claim that you simply cannot be too safe. They advocate something known as the "precautionary principle." There is no formal or universal definition of this doctrine, but it is generally taken to mean that environmental and health policies that deal with known hazards are insufficient; that we need new policies based on what "might" cause harm—even if there is no scientific evidence that a hazard exists. The precautionary crowd argues, in effect, "Stop all the technology and ban everything—just in case." To hint of *possible* harm is seductive—and the precautionary principle plays well to the crowd. Invoking it places its environmentalist advocates on the side of the public, and portrays its opponents as indifferent—even hostile—to public health and as motivated, perhaps, by some private interest in protecting a profit-making enterprise.

There are, however, at least two reasons why the precautionary principle is a myth—and why it may itself be a hazard:

First, if we act on the "mays" and the "coulds," we will have less time and less money to deal with the real health hazards.

Second, the precautionary principle assumes that no detriment to health results from a regulation targeting an alleged risk. As we will see from my examples, however, this is not true—indeed, there are some major health risks associated with the pursuit of purely hypothetical risks.

4. Mice Are Little Men

In the United States a myriad of federal and state laws and regulations assume that a mouse is a little man. This mouse-to-man extrapolation is a major factor in the success of "toxic terrorism." I called this, specifically, "mouse terrorism" because it engenders laws that cause substantial disruption of our nation's economic production (including a diminished food supply) by banning any chemical that at high doses causes cancer in animals.

Clearly, animal tests are essential in biomedical research. But so is some common sense.

First, as I have mentioned, chemicals that cause cancer in laboratory animals abound in nature. If environmentalists applied their cancer-mongering techniques to natural food, we would have to ban that, too. Second, in a laboratory test the high dose itself may cause an increased risk of cancer by adversely affecting an animal's metabolism.

The bottom line is that mainstream scientists do *not* accept a single animal cancer test on one species using one high dose as sufficient reason to label a chemical a "carcinogen." If, however, a chemical causes cancer in many species and at various doses, mainstream scientists will likely recommend that we limit human exposure to that chemical. This is how the U.S. government acts toward the natural carcinogen aflatoxin—it sets limits of exposure. But, as you will see from my next example, the self-appointed toxic terrorists want us to believe that if one rodent study shows cancer, we should all go into a national panic and banish that chemical.

5. The Dose Is Not Relevant

The most basic premise of the science of toxicology is "only the dose makes the poison." But this premise is regularly ignored by those who promote toxic terrorism Instead, they argue that if huge doses of exposure cause health problems, it follows that there is no point of zero risk—and so we should purge every measurable level of that substance from our environment. Clearly, this makes no sense whatsoever.

We know that common table salt can kill you if you ingest enough of it. But we do not reject low-level exposure to salt as a result. Yet, in some cases—cases such as nuclear energy and asbestos, both of which I will discuss presently—those espousing toxic terrorism abandon common sense and ignore the reality that the dose makes the poison.

* * *

I will turn now to my five examples of toxic terrorism. I will tell how each is hazardous to our health—and to our standard of living. In each case you will note some—or all—of the five basic myths that the extremist environmentalists promote.

A. DDT

Until the 1940s some two hundred million people worldwide were stricken annually with malaria—and at least 2 million died. But by 1946, because of DDT's remarkable effects on mosquito control and thus on the transmission of malaria, it had become apparent that DDT was one of the most important disease-preventing agents known to man.

In the words of the *British Medical Journal,* DDT was a "miracle (chemical) . . . that has been incontrovertibly shown to prevent human illness on a scale hitherto achieved by no other public health measure entailing the use of a chemical." The man who created DDT was awarded the 1948 Nobel Prize.

The anti-DDT campaign had its origins in Rachel Carson's 1962 book *Silent Spring.* That book is generally credited (or blamed) with launching the modern environmental movement. Carson's book, which focused on the alleged effects of pesticides on wildlife and suggested that they ultimately would be harmful to man, did not single out DDT. Nevertheless, DDT became the prime target of the growing antichemical and antipesticide movement of the 1960s. Two 1969 studies found that mice fed DDT developed a higher frequency of leukemia and liver tumors. The major alleged problem with DDT, however, was its effects on wildlife—and particularly its effect on eggshell thinning in birds.

Scientists came to the defense of DDT, noting that its long history of use suggested no adverse human health effects; and the government scientific advisory panel on the subject recommended that DDT not be banned. (The evidence about the effect of DDT on wildlife, and particularly on eggshell thinning, is contradictory; if there was a causal connection, it could be related to cases of overuse of the substance.)

But in 1971, avoiding all scientific consensus, the head of the Environmental Protection Agency declared, on the basis of animal studies, that DDT was a "potential human carcinogen"—and banned it for virtually all uses.

In the U.S. the ban on DDT was looked upon as the first major victory for the environmentalists, but news of the ban was received with less enthusiasm in other nations. In Ceylon (now Sri Lanka) DDT spraying had helped reduce malaria cases to a handful; but in 1964, when spraying was stopped, malaria cases again began to rise. They reached 2.5 million in 1969. Thus, DDT remains a classic case of a successful campaign by toxic terrorists to ban a useful form of technology—with a resultant deterioration of human health in some parts of the world.

And DDT remains in the news in the 1990s: Given its long half-life, DDT residues persist in the environment. Recent—and, again, unsubstantiated—charges have pointed to it as a cause of present-day breast cancer.

B. Pesticides and Food Safety

Given the laws in the United States that require the banning of synthetic food chemicals shown to cause cancer at any dose when fed to laboratory animals, and given the widespread myths about the causes of human cancer, it's not surprising that some environmental groups in the U.S. are engaged in an ongoing campaign designed to call attention to even trace levels of pesticide residues in food if the pesticide in question has been labeled a laboratory-animal carcinogen.

A well-publicized case in point is that of an agricultural growth regulator—called Alar—used on apples. Over the years, various animal tests had suggested that at high doses the chemical caused cancer in animals, but the U.S. government did not appear to consider Alar a hazard. Then, in 1989, an environmental group teamed up with a major television program and a popular movie actress to point accusing fingers at Alar. Suddenly, headlines were screaming, "Apple Products Pose Cancer Risks to Children."

Specifically this is what happened with Alar, an incident which is now regarded as a classic scare of the toxic terrorists.

An environmental group did a study claiming to show that Alar increased the risk of cancer in children. They did not take this study to a peer reviewed scientific journal. Instead, the environmental group brought it to Aemrica's #1 rated News magazine program, the TV show "60 Minutes". In addition, the environmental group hired a public relations firm which contacted radio and television programs and magazines across America and literally blanked the national with the headline "apples cause cancer". The media impact was overwhelming. Further, the environmental group engaged a famous movie star, Meryl Streep, as a spokesperson --- and after the intitial release of the claims on "60 Minutes", Meryl Streep---an actress suddenly turned toxicologist---toured the nation, appeared before the U.S. Congress and generally terrified Americans about the safety of foods treated with pesticides.

The impact was dramatic. Immediately after the "60 Minutes" program, schools across the nationa discarded all apple juice, apple pies went into dumpsters. There was a newswire report that a mother in upstate New York heard on the radio that apples caused cancer. She called the state troopers to have them intercept her child's school bus—to remove an apple from the child's lunch box. Another woman called a hotline to ask whether it was safe to pour apple juice down the drain—or if she should take it to a toxic waste dump. Apple farmers suffered enormous economic losses, and tons of wholesome food products were destroyed. Finally, as Congress threatened to ban Alar just to calm the nation down, the manufacturer announced that it would withdraw Alar from use on food.

But the Alar incident proved to be the high-water mark for the extreme environmentalists. Within months of the original scare—and principally as a result of efforts orchestrated by my organization, the American Council on Science and Health—scientists and physicians from around the world stepped forward to state the truth: The regulated, approved use of Alar had never posed a threat to the health of children or adults. The toxic terrorist movement was sorely damaged by scientists' rejection of their hyperbole. Indeed, even after eight years, anyone promoting "toxic terror" over pesticides is still hit with one inevitable question by reporters: "Is this another Alar?" The very word "Alar" has become synonymous with the word "hoax."

The environmentalist assault on pesticides is a clear example of the sort of actions their promoters tout as "pro public health" while in truth they are counterproductive to public health. Agricultural chemicals—chemicals like Alar—assure the existence of a safe, plentiful, inexpensive supply of fruits and vegetables. Epidemiologists now agree that a diet high in fruits and vegetables offers protection against a number of forms of cancer. Thus, efforts whose net result is to reduce the supply of produce through restrictions on pesticides are themselves nothing short of health hazards.

C. Asbestos

The case of asbestos—another long-time target of toxic terrorists—is another example based on the myth that dose is not important when assessing risk. Epidemiological evidence shows clearly that occupational exposure to asbestos, over many years, at high levels, increases workers' risk of lung cancer and other diseases—particularly if the worker also smokes. This was particularly and tragically true in the first decade of this century, when the risks of asbestos were not well known. Risks of disease were increased at levels of 50 to 100 fibers of asbestos per cubic centimeter of air. Lower levels were not found to be hazardous.

Yet, when asbestos was "found" in New York City public schools in 1993, no one focused on the dose—the level of asbestos present. The headlines just howled "cancer"—and in the grip of asbestos-induced toxic terrorism, the City of New York closed all its public schools for weeks. The levels of asbestos "found" in the schools were about 0.0005 fibers per cubic centimeter of air—10,000 to 100,000 times less than the amount known to cause disease. Again, remember, as the toxicological premise states: "Only the dose makes the poison." Just because something poses a health risk at a very high exposure levels does not mean that minuscule levels also carry risk.

D. Radiation and Nuclear Power

The case of radiation and nuclear power also provides an example of dose being largely ignored in rash statements about the health hazards of nuclear power plants.

Indeed, the fear of nuclear power plants is the preeminent case of Americans, and perhaps Japanese, believing the this major technology is inherently hazardous and will make the world less safe. By far the most visible and familiar obstacles to the expansion of nuclear electric-power generation arise from public concerns and misunderstandings, both about the impact of nuclear power on the environment and the risk it poses to public health and safety.

Why are nuclear power and nuclear radiation of such great concern to so many Americans? Nuclear power plants in the U.S. have a record of safety excellence dating back to 1957, when the first commercial nuclear plant began operating. Yet, in spite of this record, doubts remain.

The risks of radiation exposure, at least at high doses, are well understood in the scientific community. These risks are known with more certainty than are the risks of any other environmental pollutant. It is only at very low doses, such as those received from nuclear power plants (or from natural background radiation), that there is uncertainty about how small the effects are.

The average American's total radiation exposure is largely due to natural sources or to medical procedures that lead to increased health and prolonged life. The average American's radiation exposure due to nuclear power is negligible compared to exposures from other sources—even when you consider the expected outcome of a serious reactor accident.

In considering the health effects of radiation emitted by nuclear power plants, it is exceedingly important to be quantitative and to view the risks in perspective, along with the other risks we accept. The health risks from nuclear power are highly publicized in the media; as a result, they have generated fear in the public. But these risks are inconsequential when compared to everyday risks, including driving and flying. The radiation doses received from nuclear plants may, in fact, be lower than the doses associated with such "nonnuclear" activities as smoking, flying, or burning coal for power generation.

Accidents at nuclear power plants in Western countries have been extremely rare. When they have occurred, they have not produced serious injuries, either to plant personnel or to the public. The accident at Three Mile Island did not give rise to any serious exposures.

Although the Chernobyl accident did, indeed, have tragic consequences, the reactor at that plant differed radically from Western reactors and was operated under procedures the Russian government now concedes were inadequate.

I am not in an informed-enough condition to comment on the March 1997 radiation leak and fire at a Japanese nuclear fuel processing plant. But I understand from media accounts that workers were exposed to very small amounts of radiation.

Surely, however, this will cause serious consumer concern and make the job of defending the safety of nuclear power more difficult.

E. Biotechnology

Biotechnology as applied to foods offers enormous potential for our future. Biotechnology can be used in every aspect of the food-production system, from the farmer's field to the greengrocer's shelves. Fruits and vegetables can be picked and delivered at the peak of flavor and ripeness. Cooking oils can be produced from plants with lower saturated-fat content. French fries might be made from potatoes with enhanced starch content—potatoes that would absorb less fat during frying. Think of leaner meats from improved pigs and cattle. Think of new plant varieties biologically protected against insects and disease. Think of crops engineered to resist the deleterious effects of freezing. This is called progress!

But despite the fact that research organizations and regulatory authorities around the world have deemed the food products of biotechnology to be healthy and safe, the field of biotechnology has become the new turf for those toxic terrorists who want to put a stop to progress. Indeed, just two weeks from now, environmentalists around the world will stage simultaneous "grain dumps" and hold press conferences aimed at stopping the marketing of genetically engineered foods. Biotechnology is revolutionizing agriculture—and the extreme environmentalists want to stop it. And what weapons do they wield against the sound science on which biotechnology is based? Once again, hyperbole about risk—and mass-marketed fear.

* * *

What Is the Cause of Technophobia—and What Is the Solution?

But why do the toxic terrorists succeed in scaring the public about the products of technology, when science documents technology's safe use? This is a complex question, and I will offer you just a few answers to contemplate:

- Health, the environment and food safety are highly emotional issues; even usually rational consumers can become emotionally distraught when they hear claims that, for example, "apples cause cancer in children."

- Consumers prefer to blame outside sources, rather than themselves, for their ill health. Psychiatrists tell us that humans have long postulated the existence of invisible, hostile agents on which to blame illness or tragedy. Invisible food additives, environmental chemicals, and pesticides are perfect targets for this "projection of blame"—and having them available as scapegoats reduces an individual's need to be introspective about the personal lifestyle factors that might contribute, for example, to that individual's increased risk of cancer.

- The media supply stories about health and the environment to consumers—and the media appear to prefer bad news to good. Indeed, it might be said that bad news *is* news. We can hardly imagine a banner headline reading "Good News! Apples Do Not Cause Cancer in Children."

- The people making unsubstantiated health charges against technology often have hidden agendas. Frequently, those who purport to be protecting the public's health may actually be advancing other goals. People who object to using biotechnology to increase the milk supply, for example, may be animal-rights activists who object to the consumption of foods of animal origin. Those attacking "big business" for causing a "cancer epidemic"—an epidemic that doesn't exist—may be acting out of a deep-seated, blanket contempt for the free-enterprise system in general and profit-making institutions in particular. And, of course, those people who seek to terrify us about one particular type of technology may in fact be attempting to market and profit from a competing technology.

- And we must not forget that the manufacturer of the leading cause of preventable death in the United States—the tobacco industry—is also the second largest advertiser in the country. Only the auto industry advertises more. The cigarette industry spends $6 *billion* dollars annually in print media and on other promotions. Those dollars have long bought them silence in the media—silence about the health effects of smoking. If you look at the demographics, the same publications that carry cigarette ads generally are perfectly suited for stories that discuss the hypothetical causes of cancer. And, yes, they do run the articles—but they omit any reference to cigarettes as the number-one preventable cause of cancer.

The Solution?

So what *is* the solution to the distortion of scientific facts and the hyperbole about health risk that we see emanating from both the environmental camp and the media?

There can be but one solution: *Encourage scientists to speak out—to correct the misinformation and to state the facts in a consumer-friendly manner.* Clearly, the scientific community succeeded in this effort during the great Alar travesty of 1989. The scientists spoke, the consumers listened—and the toxic terrorists retreated.

I formed the American Council on Science and Health some 20 years ago to identify critical public health issues and energize American scientists to speak out on those issues—to target "junk science" whenever and wherever it is presented. Scientists who remain mute—who sit silently in their classrooms and laboratories while the science to which they have dedicated their lives is wildly distorted in public and in the press; who hold their opinions to themselves while unscientific laws are being passed; who stand aloof while useful and life-enhancing technologies are being rejected or banned—these scientists are *failing* in their professional responsibilities: failing their country, failing the world—and failing future generations.

Only scientists can rightfully defend science. It is time for scientists to accept this role. It is incumbent on the scientific community worldwide to provide leadership—to show the general, consuming public how to understand and quantify the spectrum of risks they hear about daily and to emphasize to the public that there are very real health risks associated with the mindless pursuit of phantom risks that have no basis in scientific reality.

And what are these real risks?

They include:

(a) the risk of creating health and environmental regulatory policies based on inverted health priorities—priorities that focus on tiny or hypothetical risks and that leave no time or resources to confront the *real* public health dangers that threaten long life and good health;

(b) the risk that, while rejecting the hypothetical risks, we may end up embracing alternative approaches to food, energy, and pharmaceutical production that in themselves carry even greater health risks.

Historically, technology, industrial wealth, and health are highly positively correlated. To put that in layman's terms, technology, wealth and health go together.

A society that rejects technology out of unfounded fear is putting its future health—and its standard of living—in grave danger. In assessing technological risks, and in sorting out the real risks from the remote or hypothetical ones, science—not politics, not emotion, and not rhetoric—*must* dominate.

Thank you.

日本原子力産業会議　午餐会スピーチ　〔要旨〕

「東と西の融合」

4／9（水）1:20～1:50
（30分　同時通訳）
於：東京国際フォーラム

〔前置き〕文化勲章を受章して

・ファッション（洋服）は、西洋の長い歴史の中でつくられてきたもの。
・その西洋のスタイルをライフワークとして、人々に助けられ４０年走り続けてきた。
・日本でファッションがやっと「生活文化」として認められたことを、大変うれしく思う。しかし、これは年をとらないといただけないものなのでは。

1. 私の歩んだ道　（日本人、日本の女として）

・パリのシャネルの店での体験

１９６１年、初めて渡仏したとき、シャネル店でシャネルスーツをつくったエピソード。「あなたの黒い髪には、太陽の色が似合う」とオレンジ色をすすめられて困った。日本では控えめが美徳とされるが、向こうでは個性を目立たせることが大切だという文化の違いを認識した。

・初めての海外のショーで表現した日本

１９６５年、ニューヨークでショーの成功。
ＥＡＳＴ　ＭＥＥＴＳ　ＷＥＳＴ――「東と西の出会い」と絶賛を受けた。
「目立つ」こと、違いを強調するため、「違い」とは何かを真剣に考えた。
それは、自分のルーツ、アイデンティティの確立である。

・１９７７年、東洋人として初めて閉鎖的なパリ・オートクチュール組合に加入。

・私の蝶は日本の蝶

今では、蝶は私のシンボルマークのように世界で言われる。
初めて訪れたＮＹで観たオペラ「マダム・バタフライ」では、蝶々夫人は哀れな日本の女として表現されていた。それ以来、「私はこの蝶々夫人のイメージを絶対に変えてみせる」と心に決めた。
１９８５年、ミラノ・スカラ座で「マダム・バタフライ」のコスチューム担当。私の蝶への思いがやっとふっきれた。

2. ファッションについて

・ファッションは時代の風

ファッションはかつては人間同士が誘惑し合う動物的なものだったが、時代とともに洗練されて、人間はどう生きるべきかの提案へと発展してきた。しかし今、おヘソを出したりするなど、再び“着る”というより挑発するムードが強調されるようになった。世紀末のせいかもしれない。

・ファッションは国境のない仕事

ファッションは早くから国境のない仕事だが、最近はインターネットなどの発達で、ますます地球が狭くなった。

・手仕事の大切さとコンピューター

コンピューターが普及し、私のスタジオにも入って便利になった。やがてコンピューターが人間の仕事を奪い、ライフスタイルも変わるだろう。

しかし、手の仕事は大事。日本の文化は職人文化、伝統をふまえて受け継いできた世界。手づくりにはしみじみした趣き、深みがある。

これからも人間の手を退化させないように。

3. 人間と科学の共存、バランスこそキーポイント

・２１世紀は科学の世紀。人間の生きざまと科学のバランスが問われる時代

２０世紀、人間は物の追求をし、自然や環境を破壊してきたため、石油の埋蔵量も先が見えてきた。天然ガスにも限りがある。その反省を２１世紀に生かす。

・これからは地球規模で、地球人として暮らすことが大切

・東と西の「出会い」から「融合」へ

ファッションは世界の共通語。フランスで受けたものは、ロシアでもアラブでもアジアでもどこでも受ける。

手づくりの文化を大切に、ファッションという創造を通して、「東と西の融合」をテーマに地球環境へのやさしさを表現していきたいと願っている。

ファッションは平和な時代の中でしか生まれない。戦争中は灰色とカーキー色の世界。日本は今ではそれほど自慢できることもないけれど、どこへも武器を売っていないことを誇りに思う。平和な社会を築いていきたい。

Nuclear Power Today and Tomorrow

Victor Mikhailov
Minister of the Russian Federation on Atomic Energy

Esteemed Mister Chairman!
Dear Ladies and Gentlemen!

Firstly, on behalf of Minatom of Russia scientists and specialists, your Russian colleagues, on my personal behalf let me congratulate you on this glorious jubilee - 30- th meeting of the Forum. The activities of the Forum are well known and there were many kind words pronounced here about it, which I have the pleasure to join to. I would like to stress that the very idea of uniting the efforts of scientists and specialists of Japan and of a number of countries, advanced from the viewpoint of economic, scientific and technological development, for resolving complicated problems in the area of peaceful utilisation of atomic energy, which has served as the basis for the establishment of the Forum, has fully justified itself. The role of the Forum in this matter is evident.

In April, 1996 there was Nuclear Safety and Security Summit held in Moscow. The Declaration adopted by the Summit says:

ê.we are committed to measures which will enable nuclear power, already a significant contributor to electricity supply in those countries choosing to exploit it, to continue in the next century to play an important role in meeting future world energy demand... ô

I would like to shortly discuss this very important problem of great international significance.

Mastering in utilisation of nuclear energy for peaceful purposes is one of the most important directions of our work. Not long time ago nuclear power industry of Russia has celebrated its 40- th anniversary: on June 27, 1954 the first in the world nuclear power unit was commissioned in the USSR in the city of Obninsk. And presently 17% of all world electricity is already produced by NPPs which are totally over 400 in number. In some developed countries the share of NPPs in electricity production is 50 to 80%. In my country this share is 12% for the country in general, while for the European part of the country it constitutes some 30% already. As far as operational safety is concerned, Russian NPPs (including Beloyarskaya NPP with BN- 600 fast neutrons reactor) are among the world best, being third after NPPs of Japan and Germany by a small margin, and better than the NPPs of France, USA, Great Britain and other countries.

These fourty years of development were not a pure success. Chernobyl disaster and the crises, which has followed it, have become a serious test for many of our contemporaries and the very idea of utilising nuclear energy. The opponents of utilising nuclear energy have become much more active and, as it has already been happening during similar historical transition epochs, there are inquisitors of the new science even in the 20- th century.

But it is impossible to bring the development of science and technology to a hault!

The improvement of the nuclear safety of Russian nuclear facilities goes on. 1996 alone has witnessed the expenditures of 350 mln. US$ for research, developmental and technological works aimed at improving NPPs safety. Presently we can assure that another Chernobyl disaster is practically excluded.

Alongside with improving NPPs operational safety a great deal of attention is being paid to the new generation of reactors.

Both Russian and foreign studies demonstrate that the utilisation of alternative power sources is possible to a limited extent only. One should also take into consideration the danger of green- house effect and of ozone layer destruction due to the exhaust of fossil fuel combustion products.

All the above mentioned means, that the humankind cannot manage without nuclear power resources. The subjects of discussions are the scale and rate of development and profitability of nuclear power with the proper consideration for its safety.

IAEA assessments of July, 1996 predict the growth of installed capacities of NPPs in the world by 2015 from 8.6% , i.e. up to 374 GW (the lowest estimate) to 56% , i.e. 537 GW (the highest estimate). Simultaneously it is expected that by the same date NPP installed capacities will decrease in Western Europe and North America, while the growth is expected in the countries of the Middle East, Southern Asia and especially in the Far East, i.e. in Japan, China, Republic of Korea and other countries of the Asian- Pacific region.

By the assessment of a number of experts, in case the growth of NPP capacities in the world up to the year of 2015 will go on in accordance with the averaged estimate, then after 2015...2020 this growth will accelerate considerably, because by that time NPPs with ultimate safety will be implemented, the problems of radwaste disposal will be practically resolved and the future of the thermonuclear power will become clear.

Minatom policy takes these trends into consideration. Simultaneously I would like to stress that Russian scientists and engineers are ready to create NPPs with ultimate safety. Even in the middle of the 70- ies Soviet nuclear power science have started active development of NPPs with "inherent" and "passive" safety and the idea of establishing nuclear thermal plants, to be situated close to large cities and thus obliged to have high safety level, was put forward. These ideas were implemented in the design of nuclear thermal plants, which were built, thus putting Russian nuclear engineering science 15- 20 years ahead of the world level.

These developments were incorporated at a contemporary technological level into the priority projects of NPPs with water- cooled water- moderated reactors with 640 and 1000 MW (el.) capacity. The development of such NPPs provides the opportunity to plan commissioning of power units soon after 2000 and then, after a definite period of pilot operation, to start large- scale construction of such NPPs.

It is appropriate to mention the changes in the public acceptance of nuclear power in Russia, which is slow and gradual. A number of regions have chosen NPP construction as the option of power capacities development. It should be noted that any power source is associated with definite risks and has its specific advantages and disadvantages.

The development of NPPs and nuclear thermal plants of new generation is based on their natural safety, which eliminates uncontrolled chain reaction, and on closed fuel cycle incorporating safe system for radwaste management. Presently the projects of NPPs of both high and low capacity with inherent safety and isolation of fission products - in case of any incident - inside the reactor vessel are developed. These projects have successfully passed the most detailed international reviews.

Presently a nuclear reactor in not only a thermal and electrical energy source, but it also provides the possibility for regeneration of nuclear and thermonuclear fuel, synthesis of artificial elements, modification of materials to render new properties to them and for production of radioisotopes for medicine.

The implementation of nuclear power development in Russia is directly associated with stabilising of the national economy. However, the stability of nuclear power complex is an important component of national economy stability. Every year Russian NPPs increase the production of electricity - 1996 has witnessed 10% growth in comparison with 1995.

Russian export of low- enriched uranium and NPP fuel resulting from high- enrichment weapon- origin uranium disposal, as it is implemented in Russia- US Agreement of 1993, is an additional source for funding nuclear power development and improving its safety level. The long- term supply of Russian power- grade uranium manufactured from weapons- grade material in mutually agreed quantities may become a real contribution to nuclear disarmament as well as an economically expedient option for the nuclear power program of Japan.

Russia is the first country in the world to adopt the strategy of turning megatons of TNT equivalent into megawatts of electricity - this is the real way to nuclear disarmament!

In this context I would also like to mention about Russian technologies of mining of precious metals and stones by means of underground leaching and boring out, which are very promising for the world market, but face with great difficulties in entering it.

Fast neutron reactors, nuclear transport propultion units, low-capacity nuclear power units, desalination of sea water - these are the directions for co- operation, aren ât they?

Today in the uranium products exports we already have high added value due to the utilisation of modern technologies. Still, I think that there are high potential benefits to be gained from NPP electricity exports.

We have no doubts that Russia is capable of tackling its technical and economic problems itself. However together with the international community this can be done much faster and more effectively. It is absolutely evident that utilisation of economic and ecological advantages of nuclear energy requires a close international cooperation, including the world market and mutual support of national programs.

It is also important to emphasise that new advanced long- term projects should be undertaken jointly by different countries since such projects require large financial and intellectual resources and that is burdensome just for one country. An example of this is the joint development of the international thermonuclear energy reactor (ITER) with the participation of Japan, USA, European Community and Russia.

The development of helium- cooled high- temperature reactors as well as our joint works in the area of development of granulated nuclear fuel, including MOX- fuel, as well as nuclear power radwaste dry treatment - all these works demonstrate that in the area of nuclear power we have really come to the principles of team work.

The XXI- st century nuclear power should be based on the combined efforts of the industrially developed states with due consideration of the interests of developing countries in our world.

The issue of supplying nuclear fuel as well as rendering services in spent fuel disposal to all countries which have already understood the advantages of nuclear power is in the agenda of the day. Russia also welcomes such non- traditional approaches as nuclear power by itself demands it.

To my mind this area of joint scientific and commercial cooperation has no limits.

In this presentation I should also point out to the existing possibilities of the expansion of mutually beneficial cooperation between the organizations of the RF Minatom and Japan. Significant positive experience has already been accumulated in this area. As an example one could cite the construction of the full- scale simulator for the reactor VVER- 1000 in Novovoronezh and also another big joint NPP safety enhancement project which includes the development of the leaktightness control microphone system for the Leningrad NPP- I using high- temperature resistant microphones developed in Japan. We appreciate the efforts of the Japanese side directed towards our mutual aspirations of safe nuclear energy. Both sides keep to the opinion that these joint work can grow into large commercial projects.

This year we celebrate 20- th anniversary of signing the Agreement with JAIF. A good basis for the cooperation between our countries is the similarity of scientific and technological tendencies in the development of nuclear power both in Japan and Russia. Japanese experts constantly demonstrate their interest in the more complete utilisation of the energy potential of the nuclear fissile materials, resolving at the same time the issue of the disposal of long- lived transuranium elements, and support the research in the field of fast neutron reactors together with the promotion of new generations of traditional light- water reactors, including the utilisation of such reactors for the disposal of weapon- origin Pu.

In the field of scientific and technological cooperation with respect to the joint development of promising scientific projects we welcome the decision of the Japanese side to join the development of the HTGR reactor with the direct gas cycle - the project already being jointly carried out by Russia, France and USA. This project is highly rated from safety and cost- effectiveness points of view, as well as from the view point of disposal of weapon- origin nuclear materials.

I propose to continue and develop Russian- Japanese cooperation in the field of fast neutron reactors. Minatom of Russia makes the proposal to take part in the construction of the BN- 800 reactor in the vicinity of Beloyarskaya NPP in the Urals. This would constitute a new phase of the scientific, technological and commercial cooperation providing the Japanese experts with the most recent data on the Russian fast- neutron reactor technologies and possible commercial use of the generated electric power in the industry of the Urals area.

We have a wide choice of projects that are prospective from both scientific and economic points of view. Let à co- operate!

We know a lot about the economic ôwonder ôof Japan, France, Germany and South Korea that took place after the WWII. As a matter of fact that was conditioned by commercial application of nuclear power in these countries and extensive construction of nuclear power plants on the basis of wide- scale co- operation.

Having signed the Comprehensive Nuclear Test Ban Treaty (CTBT), Russia has demonstrated its will to use the atomic energy for exclusively peaceful purposes. In 1996 the Soviet nuclear weapons withdrawal from the countries of Commonwealth (CIS) to Russia for dismantling was completed.

One of the main aspects of the Russian weapons industry activities is the disposal of nuclear warheads under the Nuclear Weapons Reduction Programme. Today the volume of these operations exceeds significantly that of the nuclear warheads serial production, and presently our nuclear arcenals are cut by half.

I would like to say few words about the conversion of enterprises within Minatom cognisance. In 1996 the conversion took place at 60 industrial enterprises and at more than 30 research organisations within the branch. We are sure that Russia is not alone in its interest to switch these enterprises and their personnel to the civil sector. Unluckily, the investments are insufficient. Significant contribution to funding of conversion process belongs to the International Scientific and Technological Center co- founded by the USA, EC, Japan and Russia. Establishing, within the conversion framework, of joint- stock enterprises with the involvement of foreign investments, including the Japanese ones, shall be mutually beneficial and shall contribute to peaceful process and further bringing together the nations.

We look at the extensive economic development in Asian- Pacific region, which is our neighbour, with growing interest. It is obvious that, in XXI- st century this momentum will be passed to the countries of this very region, which already show an increasing interest in this process nowadays.

I would like to declare that we are ready to the widest international co- operation with the countries all over the world - both with developed and developing, with neighbouring and distant ones. But we are strongly against any discrimination, double standards and twofold approaches to co- operation issues as well as against resolving conflicts by force.

The gift presented to us by our Green Planet - the fossil fuel - shall not be burned in stoves, but saved for our ancestors to be used more effectively and efficiently. We must do our best to prevent the satisfaction of our energy needs at the cost of the capabilities of the future generations to develop. The development of nuclear power in all countries, as the basis for scientific and technological progress, will help the future generations to gain a new vision of peaceful co- operation, to live in the world without regional conflicts.

Minister of Atomic
Energy of the Russian
Federation

V.MIKHAILOV

The Progress of China's Nuclear Energy Program

Li Dingfan
Vice President
China National Nuclear Corporation
April, 1997

Mr. Chairman, Ladies and Gentlemen,

It is my pleasure to have the opportunity to participate in the 30th Annual Conference of Japan Atomic Industrial Forum. Please allow me, on behalf of China National Nuclear Corporation to extend my heartfelt felicitation on the convention.

Now, I would like to take the chance to introduce the current status and prospect of China's nuclear energy program, mainly nuclear power and nuclear fuel industry.

I. Current Status of China's Nuclear Power Program

In this world, China is the nation with fast economic growth and increasing demand for power supply. China decides to continue the nuclear power development in coastal provinces in order to ease the tension of power supply in that region. The year of 1996 is regarded as the crucial year of start to development for China's nuclear power program. The construction of 4 nuclear power projects planned for the Ninth Five-Year Plan period, i.e.

1996 to 2000, has been in full swing. A new nuclear industrial system with nuclear power as the leading effort has come into being. China's nuclear power installed capacity is estimated to reach 20,000MW by the year of 2010.

Qinshan NPP and Daya Bay NPP maintain safe and steady operation. In 1996, the former has a load factor of 84.7%; the latter has a load factor of 70.1% due to the local grid demand for electricity. The monitoring results of the two NPPs show that there is no negative effect on environment.

During the Ninth Five-Year Plan Period from 1996 to 2000, China plans to start the construction of 4 nuclear power projects. The 8 units come to the total installed capacity of 6900 MW.

For Qinshan II NPP with independently-designed 2x600 MW PWR units, June of 1996 saw the first concrete pour to start the full-scale construction. It will be completed by the year of 2003.

Ling'ao NPP in Guangdong is imported 2x1000 MW units. The excavation work for the nuclear island has been started. The first concrete pour is scheduled for May 1997. The project is expected to be completed in 2003.

Qinshan Phase III NPP of 2x700MW CANDU-6 PHWR units is introduced from Canada. The commercial contract has been signed by both parties and was formally approved by the governments of China and Canada. We expect the project to be started in June, 1998 and the completion in 2003.

Lianyungang NPP in Jiangsu Province is a Sino-Russian nuclear energy cooperative project. 2 PWR units of VVER-1000 improved type-91 are introduced from Russia. The construction of this project is planned to be started by the end of 1998. The first unit is to be completed in 2004.

China's nuclear power progress has triggered the development of research and design, nuclear fuel assembly fabrication and other related industries. Nuclear industry plays a growing role in the national economy.

II. Basic Policy, Current Status and Prospect of China's Nuclear Fuel Industry

1. Basic Policy

With the consideration of the domestic condition and reality of nuclear industry, following principles apply to China's nuclear fuel development: combination of opening-up and domestic orientation of fuel supply; principle of peaceful use of nuclear technology for nuclear power program to set up brand-new modernized nuclear fuel industrial system to match with nuclear power development; adoption of nuclear fuel cycle strategy of reprocessing spent fuel of power reactor; abiding by the state regulation on radiation protection and environmental protection to ensure the safety of nuclear facilities and personnel.

Policy and technical guideline are as follows:

· to rely on the domestic nuclear fuel resource and to increase the efficiency of the resource;

· to promote in situ leaching and heap leaching technology application for uranium mining and metallurgy;

· to shift from diffusion technique to centrifugal technique for uranium enrichment production;

· to introduce international new technology for fuel assembly fabrication to supply international-level quality fuel assemblies; meantime, to vigorously develop new types of nuclear fuel element with improving technical feature and decreasing fabrication cost;

· to adopt close nuclear fuel cycle for spent fuel reprocessing;

· to minimize the rad waste output; to speed up the solidification and disposal of medium and low-level radioactive liquid wastes; to conduct the regional disposal of medium and low-level solid wastes in near surface; as well as concentration disposal of high-level radioactive solid wastes in deep repository;

2. Current Status and Prospect of China's Nuclear Fuel Industry

China has explored a certain quantity of natural uranium reserves and theoretically the uranium resource supply is guaranteed. According to the forecast of China's electric power development, by the year of 2010, the capacity of 20GW nuclear power will demand 3000 ton uranium per year; by the year of 2020, the capacity will reach over 40 GW. Based on the current status and potential of China's uranium resource, plus the further uranium exploration and development, China can fully cater for the domestic demand with certain surplus.

To meet the demand of nuclear power program, China is speeding up the construction of centrifugal enrichment plant as well as the R&D of in situ leaching mining technology. Meantime, we are working preliminarily on the HWR fuel production line. China has obtained the capability of mass production of NPP fuel assembly for 300MW, 600MW and 900MW NPPs.

By the end of 1996, Qinshan Phase I NPP, Units 1 and 2 of Daya Bay NPP in operation have unloaded a total of approximately 140 ton spent fuel. Besides, some spent fuel has been unloaded from research and experiment reactors and now is stored in the storage pools of the facilities.

China plans to build a large-scale commercial reprocessing plant in around 2020 and a pilot facility for MOX fuel R&D in the near future. In order to acquire the construction and operation experience of commercial reprocessing plants, China is constructing a pilot plant with a designed capacity of 300Kg/day in Lanzhou Nuclear Fuel Complex. It is expected to be put into operation by early next century. Also, a central storage facility of spent fuel is under construction.

In China, the system of regulation and standard on rad waste management has been established. Up to now, the 50 items of state standards and nuclear industrial standards that were decreed and are being compiled have basically met the requirement of rad waste management. For high radioactive liquid waste treatment, China has decided to adopt ceramic electric furnace vitrification technique. The full-scale simulation device is to be put into experiment. For mid-level radioactive liquid waste disposal, we adopt underground hydraulic fracture and bulk grouting cementation process. The hydraulic fracture facility was put into trial operation successfully at the end of 1996 and the bulk grouting facility will be soon put into operation in the coming years. For low level liquid waste treatment, bitumen solidification is adopted with sound operation record of its facility for several years. The low level liquid waste discharged by NPPs undergoes cementation after concentration at site.

China adopts regional disposal principle for low and mid-level radioactive solid wastes. Northwest Low and Mid-level Activity Waste Disposal Site is to be completed in 1997; Beilong Disposal Plant located in Guangdong Province is planned for commercial operation in 1998; The site selection of East China Disposal Site has been started.

III. Nuclear Safety and Environmental Protection

In the course of nuclear energy program, China sticks to the basic principle of "safety priority, quality priority" to set up safety environmental protection and health care system at all levels. To ensure the quality and safety of nuclear power construction and operation, China has established complete nuclear safety regulation system and formed a complete nuclear safety organization with National Nuclear Safety Administration, as the major nuclear safety regulatory agency and other corresponding nuclear safety control bodies. China's government, through the regulations and this organization, exercises comprehensive review and supervision of NPPs and other nuclear facilities. While ensuring the safety of nuclear facilities and personnel, we attach importance to the campaign of public safety and environmental protection awareness to build good image of nuclear energy program.

With the focus on the nuclear power safety, we undertake all the efforts of the safety and environmental protection in the nuclear fuel industry. The top priority is to guarantee NPP operation safety, especially the safety supervision and radiation protection in the course of refueling repair and maintenance; Meantime, we attach importance to safety supervision and inspection in fuel cycle; We constantly abide by the nuclear safety regulation and implement the nuclear safety and environmental protection measures; We stick to the rad waste management policy with the focal point of disposal. CNNC enjoys a complete nuclear accident emergency system including emergency agencies and necessary emergency facilities located in NPPs and related nuclear facilities.

IV. International Cooperation in Nuclear Energy

Ladies and gentlemen,

In the initial phase of start-up to development, China seeks extensive international cooperation to jointly explore the market of nuclear power and nuclear fuel.

1. Chinese government constantly sticks to the following three principles for nuclear export:

1) Use of nuclear energy only for peaceful purpose;
2) Request the nuclear importer governments to accept IAEA safeguards and supervision;
3) Without mutual consent of both sides of cooperation, no transfer to the third country.

2. International cooperation is an integral part of China's nuclear energy program; The development in China's

nuclear power and nuclear fuel industry brings about a broad nuclear energy market to the world.

Experience acquired in China's nuclear power development has proven the importance of international nuclear technical exchange as well as further sharing and introduction of technology, funds, management experience and personnel for nuclear power and fuel fabrication. China will maintain and develop the international cooperation in nuclear power and nuclear fuel with other countries including Japan and join with them in contributing to nuclear power development and economic prosperity in this region.

Thank you all.

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SESSION 1

30th Japan Atomic Industrial Forum Conference

Energy Security Issues Facing the World

Session I:
"Alternative Energies: Roles and Prospects"

by
William F. Martin
Former U.S. Deputy Secretary of Energy
Former Executive Secretary of the U.S. National Security Council

April 9, 1997
Tokyo, Japan

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INTRODUCTION

Thank you very much for inviting me to participate in the Japan Atomic Industrial Forum's (JAIF) 30th Annual Conference. It is a great honor and pleasure to be here with you. My good friend and Trilateral Commission co-author—Professor Ryukichi Imai—has told me much about JAIF and all the excellent conferences you have held over the years.

This afternoon, I would like to focus my remarks on what I believe are some of the key "energy security issues" facing the world, both in the short and long-term.

In preparing for my speech, I have drawn upon the principal conclusions of our recently published Trilateral Commission report, *Maintaining Energy Security in a Global Context.*

The speech is divided into six areas:

1. World Energy Supply and Demand Over the Next 15 Years
2. Rising Dependence on the Persian Gulf
3. Medium to Long-Term Environmental Challenges
4. Energy Scenarios—Fifty Years Ahead
5. Nuclear Power and the Importance of the Japanese Nuclear Energy Program
6. Conclusions

PART I:

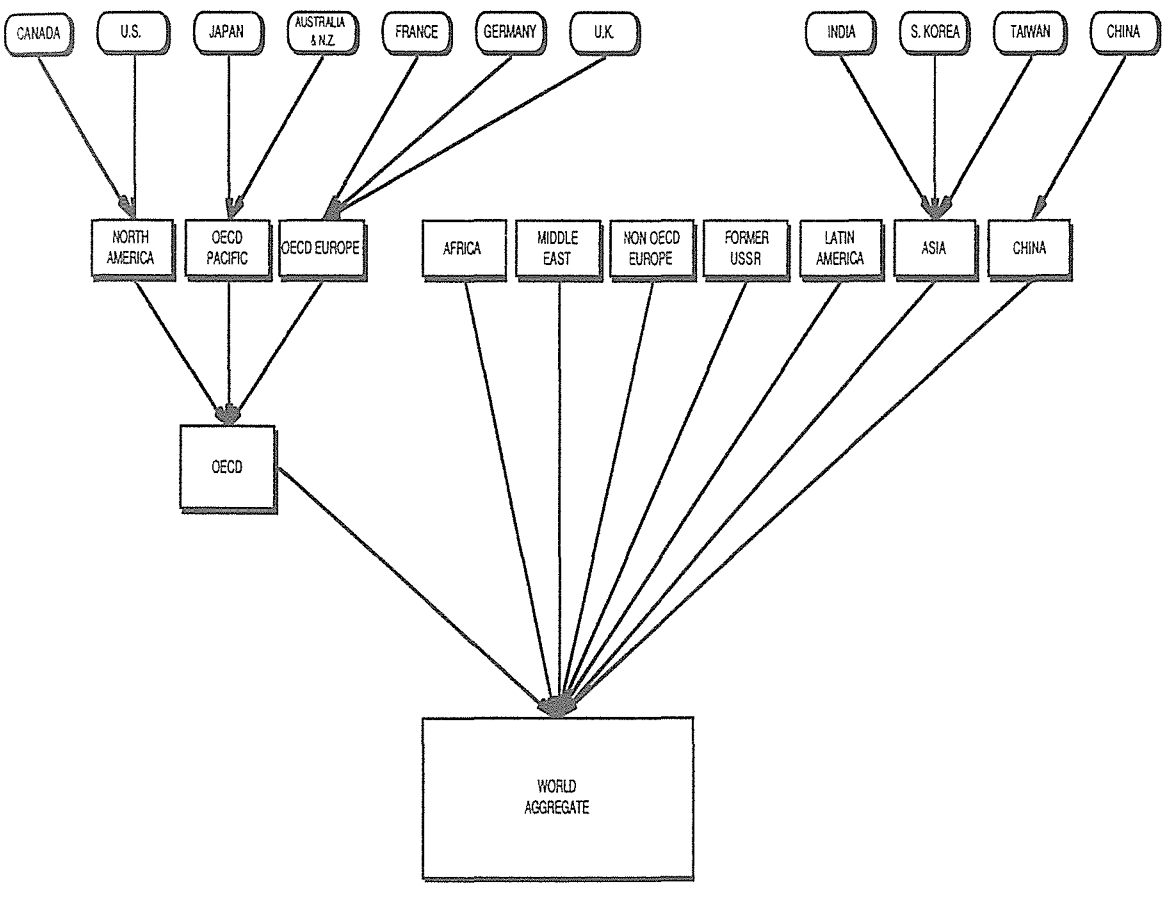
WORLD ENERGY SUPPLY AND DEMAND OVER THE NEXT 15 YEARS

A. GEMS Model Calculation Process

Our tool for examining world energy supply and demand over the next 15 years is the GEMS Model. The GEMS approach was first developed at MIT by Carroll Wilson and the Workshop on Alternative Energy Strategies, where I served as a program officer 20 years ago.

It is a relatively "assumption driven" model, based on a number of factors regarding economic growth, oil price, and fuel preferences. As shown in Figure 1, the GEMS Model includes estimates of energy supply and demand for 11 countries, 10 regions and a global aggregate.

Figure 1: Calculation Process for GEMS World Aggregate



It is therefore possible to look at fuel mix shifts and to estimate what it would take to reduce dependence on a particular fuel for security or environmental reasons. The model has over one million cells in an Excel spreadsheet format.

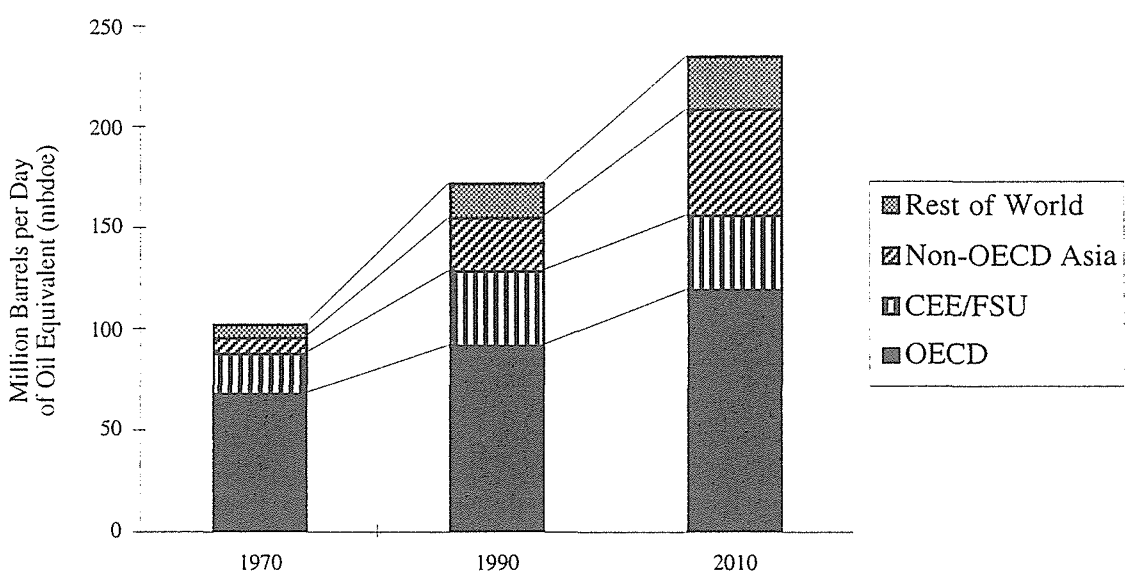
We start with economic growth and here we include private estimates of the OECD secretariat. These estimates tend to be lower than member government estimates. We have conservative estimates for world economic growth over the next 15 years—2.3 percent for OECD countries and 5.3 percent for non-OECD countries. Estimates of economic growth for the rapidly industrializing countries are somewhat higher than that of the more "mature" OECD economies.

B. Global Energy Supply and Demand

Free trade and the proliferation of market economies is propelling the world toward a new era of economic prosperity. While this rapid economic growth is raising living standards in many of these nations, it is also resulting in a dramatic expansion of global energy demand.

Our GEMS Model projects that world energy demand will likely increase by approximately 40 percent between now and 2010. As shown in Figure 2, OECD countries will constitute a smaller share of much greater world energy consumption than was the case in the early 1970s.

Figure 2: Energy Consumption by Region (1970-2010)



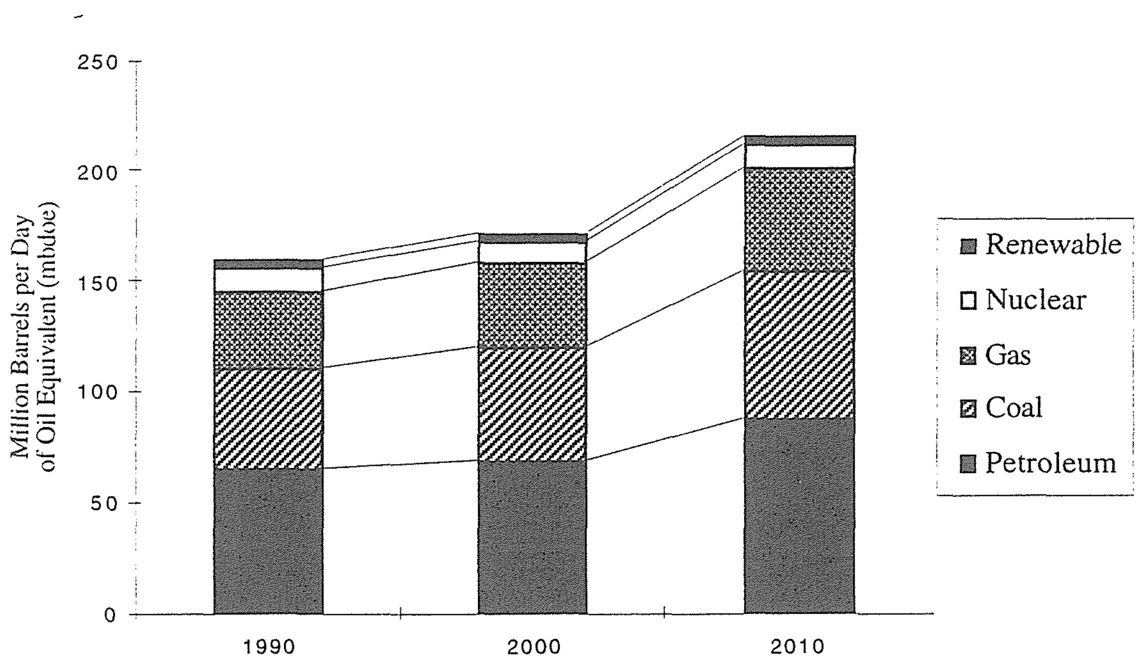
Source: GEMS Global Energy Supply and Demand Model.

This rise in global energy demand is occurring largely as a result of the increasing liberalization of markets which has facilitated a shift in manufacturing away from industrialized economies (such as those in the OECD) to rapidly industrializing economies (such as those in Asia). Think of the basic steel production shifting from the United States and Europe to Japan, and then to Korea, now to Thailand and other Asian economies. These industries, such as the steel industry, use a greater amount of energy per unit of gross domestic product (GDP) than the more service-oriented economies in OECD countries.

Energy demand is also expanding because of the increasing percentage of populations living in urban areas. Urbanization (the growth in proportion of a country's population which lives in towns or cities) not only leads to greater demand for refrigerators, televisions, and electric fans, but also is directly related to the rise in demand for motorized transport.

Energy systems do not change much in 15 years, and accordingly, as shown in Figure 3, the GEMS Model projects that the world will continue to rely on fossil fuels to meet the majority of its energy requirements.

Figure 3: World Primary Energy Demand by Fuel (1990-2010)



Source: GEMS Global Energy Supply and Demand Model.

C. Regional Energy Supply and Demand

Now that we have examined energy demand and supply patterns at a global level, I think it will be helpful to examine the regional energy demand and supply structure.

North America (including the U.S., Canada, and Mexico) has a large natural resource endowment and consequently, many different energy options. Natural gas has been the fastest growing energy source over the past several years. This has come about as a result of several different factors, including the implementation of the North American Free Trade Agreement (NAFTA) and deregulation of energy markets in general. Changes in the U.S. electric utility industry, environmental regulations and improvements in combined cycle technology will ensure that natural gas will be the fastest growing fuel over the next 15 years. Other fuels, such as oil, coal, and nuclear will retain their share in the overall energy mix. Nuclear energy's role will begin to decrease in the post-2010 period as many plants are slated for decommissioning.

European countries represent a variety of different energy situations. Some are producers (such as Norway, which is the second largest exporter of crude oil in the world); others are consumers. Some have pursued aggressive nuclear power programs, such as France and Belgium, and others such as Italy have relied on oil for electric generation. We expect the energy demand/supply structure to remain largely reliant on fossil fuels over the next 15 years, with natural gas as the fastest growing fuel source.

Over 80 percent of Japan's energy needs are met by imports—including all of its oil, about 70 percent of which originates in the Middle East. Consequently, diversifying its energy supply structure is the primary objective of Japan's energy policy. Expanding its nuclear energy program is a principal part of this plan, including the development of a closed fuel cycle. The Japanese government's target of having nuclear energy provide approximately 40 percent of electric generation by 2010 will require the addition of approximately 15 nuclear reactors.

The rapidly industrializing countries of Asia will account for a large percentage of the increase in global energy demand over the next 15 years. Sustaining real economic growth rates of between 6 and 8 percent will require massive amounts of energy. We expect these countries to rely on the most inexpensive fuels—largely oil and coal—to satisfy their expanding energy appetites. For example, we project that China will rely on coal for 75 percent of its primary energy share in 2010.[1]

This raises an important, yet sensitive issue: the need for the industrialized [OECD] countries to take the lead in using the most advanced energy technologies, which are also the most expensive. Less industrialized countries will rely on the cheaper energy technologies, just as we did during our earlier stage of development. It is important to note, however, that these "cheaper energy technologies" will still be much more efficient than the technologies we

[1] China will be the single largest source of greenhouse gas emissions during the next 15 years.

used 50 years ago. A coal plant being built in China today is far more advanced than one that was built in the Ohio Valley just after World War II.

Now that we have examined energy and demand patterns over the next 15 years, what trends emerge?

The energy portfolios in OECD countries will remain relatively balanced, with a mix of fossil fuels, nuclear, and renewables. However, beginning in 2010, nuclear generating capacity in many of these countries, with the exception of France and Japan, will decline—increasing our reliance on fossil fuels.

The rapidly developing countries, especially those in Asia, will use an increasing percentage of fossil fuels, especially coal, because of its abundance and low cost. By 2010, fossil fuels will account for 80 percent of East Asia's primary energy supply.

What type of energy security issues does this likely pattern of energy supply and demand over the next 15 years raise?

PART II:

RISING DEPENDENCE ON THE PERSIAN GULF

A. Increasing Dependence on Persian Gulf Oil

Based on our GEMS Model energy projections over the next 15 years, I believe we face a daunting energy-related national security challenge associated with our increasing dependence on oil from the volatile Persian Gulf. It is problem that will be especially challenging for Asian countries, who according to estimates by the U.S. intelligence community, will be importing approximately 90 percent of their oil directly from the Persian Gulf.[2]

Many in the energy community discount the nature of the energy security threat that is before us. They argue that improvements in oil recovery technology, stable fiscal regimes, and the emergence of a global oil market lessen the significance of Persian Gulf oil producers and thereby minimize the concept of energy security.

Furthermore, persons claiming this view believe that in the event of another crisis in the Persian Gulf, such as an attack on Saudi Arabia or Kuwait, the U.S. would respond immediately by sending 500,000 troops to the region and restore order, thus ensuring the stable supply of oil to world markets.

I disagree wholeheartedly with this point of view. In fact, I believe we are in an even more perilous situation than that we faced during the 1970s, 1980s, and early 1990s—a period during which we experienced an oil disruption due to geo-political events on average every 5 years.

There are several reasons as to why I believe our increasing reliance on oil from the Persian Gulf poses a significant national security threat:

- Rising Oil Demand: Oil demand is rising at an unprecedented rate and will continue to be the world's most important energy source. It will account for over 40 percent of global primary energy supply in 2010. Without stable and affordable supplies of oil, the global economy will grind to a halt. Much of this oil demand over the next 15 years will originate in the rapidly industrializing economies of East Asia. They will account for a greater increase in annual oil demand than the whole of the OECD. This growth in oil demand is being fueled largely by an expanding transportation sector.

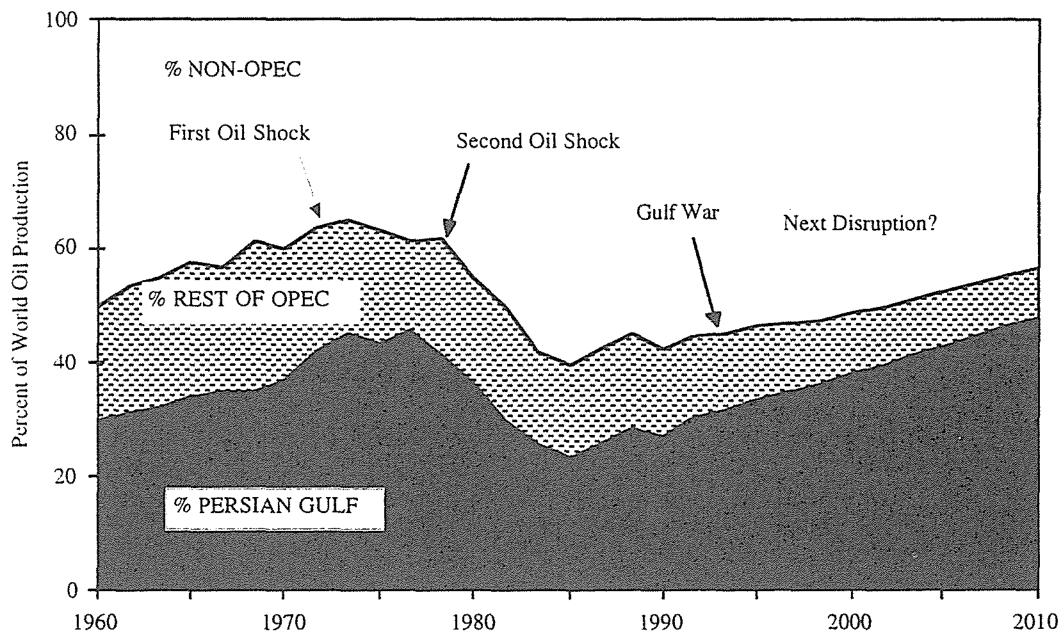
- Non-OPEC Production: OECD regions, especially the North Sea and parts of North America, have experienced impressive gains in oil recovery rates in the more mature fields. Other parts of the world (non-OECD) are also increasing oil production as the result of more stable fiscal regimes and technological improvements. Nevertheless, with projected increases in worldwide oil

[2] By 2010, import dependency on the Persian Gulf will rise to 95 percent.

consumption, steady non-OPEC oil production represents a declining share of total world oil supplies.

- Persian Gulf Swing Producers: Despite the positive prospects for steady (instead of declining) non-OPEC supply of oil, the world's incremental oil demand will have to be met by OPEC producers—and within OPEC by the Persian Gulf producers: Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates. As demonstrated in Figure 4, it is the percentage of world oil supplies provided by the Persian Gulf producers (not OPEC overall) which we project rising to mid-1970s levels around 2010. Persian Gulf exporters, with enormous reserves and low production costs, promise to be the key swing producers in meeting the world's increased demand for oil.

Figure 4: World Dependence on Persian Gulf Oil



Source: GEMS Global Energy Supply and Demand Model.

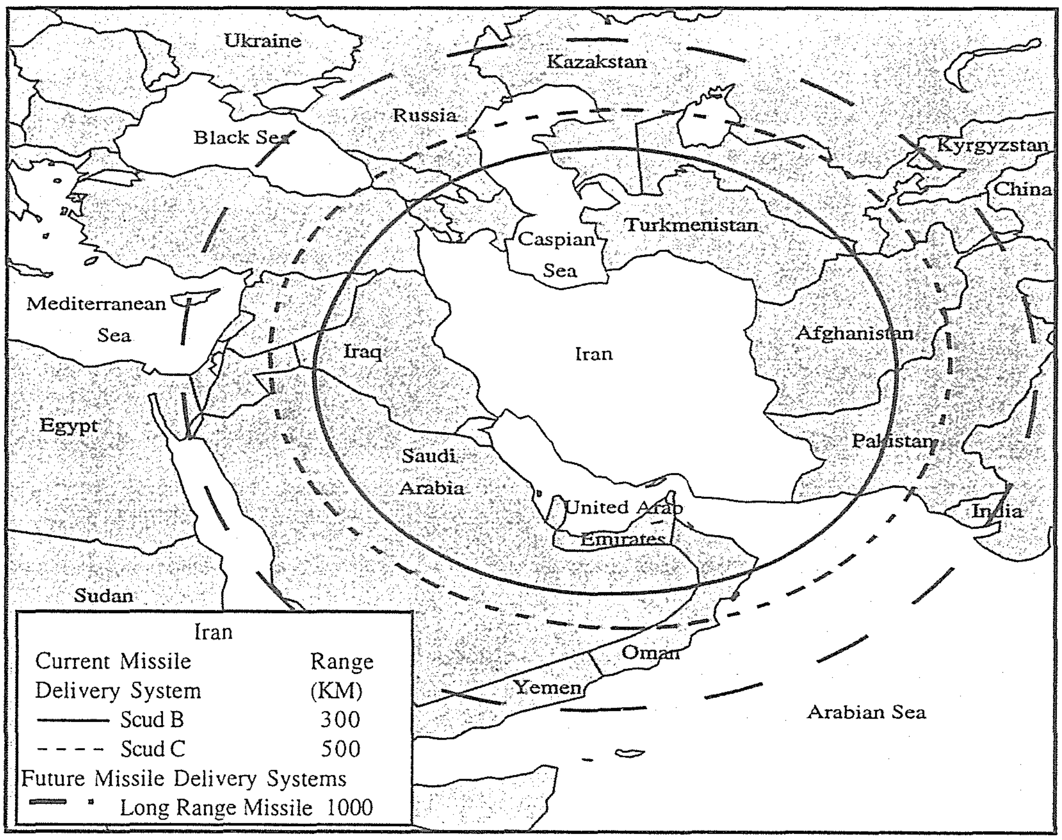
B. Obstacles to Stable Oil Supplies from Persian Gulf

Certainly the Persian Gulf swing producers—Saudi Arabia, Kuwait, Iran and Iraq—could produce this amount of oil based on their reserve potential, but there are serious obstacles:

- Unstable Investment Climate: Governments in the region face daunting socio-economic challenges in the coming decades. Past economic policies, based on state-directed investments and subsidies paid by oil rents, are no longer viable. The challenges of restoring economic growth, restraining population growth, creating jobs, providing food, conserving water, and protecting the environment will require large sums of money. Only the private sector, both domestic and foreign, can provide the necessary funds. Yet if such investments are to occur, stable and predictable "rules of the game" for private investors must be established.

- External Threats: Defending against *external* threats to a key producing country—such as Iraq's invasion and annexation of Kuwait in 1990 or the war between Iran and Iraq in the 1980s—is of central concern and is becoming more challenging. Advancements in military technology, especially the development of weapons of mass destruction (nuclear, biological, and chemical) by pariah states, raises questions about future U.S. military activity in the region with the purpose of defending against external threats. The U.S. Department of Defense has recently released a report outlining Iran's commitment to developing weapons of mass destruction and the threat this imposes on the region. As Figure 5, illustrates, present day Iranian ballistic missile technology would enable it to strike targets in neighboring countries, including oil installations and ports in Saudi Arabia.[3]

Figure 5: Iranian Ballistic Missile Technology



[3] Office of the Secretary of Defense. *Proliferation: Threat and Response,* (U.S. Department of Defense, April 1996).

- Internal Threats: Defending against *internal* threats—such as the collapse of the Shah's regime in Iran, which brought about the second oil shock in the late 1970s—is one that is difficult for outside nations, such as the United States, to influence. Several monarchies in the Gulf, such as Saudi Arabia, are in the midst of transferring power to a younger generation. If we support the current monarchical structures, which are often undemocratic, are we supporting long-term revolutions, as was the case in 1979 in Iran? On the other hand, if we withdraw our support for these established regimes, would they fall into the hands of radical clerics, as is the case of Iran today?[4]

C. Optimistic Viewpoint

What could change this picture, remembering that our outlook period extends to 2010, which is not a long time in terms of energy planning?

- Lower Oil Demand: Oil demand could be lower than we project. However, our GEMS Model projections are based on conservative estimates of future economic growth. These projections are actually lower than almost all other comparable models. For example, we estimate Chinese economic growth at a relatively low average rate of 6 percent during the outlook period, compared with OECD's estimate of 8 percent and the World Bank estimate of 10 percent. We also assume improvements in energy efficiency. Therefore, if anything, we have erred on the low side of energy [oil] demand. It could, in fact, be higher.

- Technological Improvements: Breakthroughs in oil recovery technology are an important reason for the better-than-predicted non-OPEC oil production over the past decade. Improvements in recovery rates have brought about reductions in cost to the point where North Sea recovery costs are less than half what they were a decade ago. In our model, however, we account for improvement in recovery, and in fact, we show an increase in non-OPEC production for the forecasted period (1990-2010). Many forecasters will say that this is too optimistic, but we believe it is realistic given advancements in 3-D seismic, horizontal drilling and other technologies. Nevertheless, the rate of world demand for oil easily outstrips the capability of non-OPEC countries to meet that demand, resulting in rising dependence on Persian Gulf producers.

- Alternatively Powered Vehicles: The transportation sector is almost totally dependent on oil. Demand for oil will rise corresponding to the rapid growth projected in the transportation sector. One way of slowing that growth in oil demand would be the wider use of alternatively powered vehicles. In the

[4] Some have suggested that despite the chaos and confusion from an internal revolution, the successor regime would still have to sell oil in order "to eat." This may be the case at the end of the revolution, but what happens during the interim fighting that may involve rival factions and last several months? A sudden drop in oil production from any of the major Persian Gulf producers for even a period as short of 3 months would wreak havoc on the global economy. Recall that the oil crisis of the 1970s became the international debt crisis of the 1980s.

short-term, this could involve greater use of natural gas, and other fossil fuel derivatives. Over the long-term, electrically powered vehicles could significantly reduce our oil consumption; however, unless a technological breakthrough occurs in battery technology (which would both extend their range and reduce their cost), electric vehicles will not make any significant impact on the transportation sector until well after 2010. Furthermore, it takes time to build distribution infrastructure and the rate of auto replacement on average is only once every 10 years. Therefore, it may be 20 to 30 years before we see a significant (say 25 percent) increase in market share of alternatively powered vehicles.

- Emergence of the Former Soviet Union as Major Oil Exporter: During the 1980s, Russia was one of the largest crude oil producers in the world. In 1987-88, its production peaked at 12.5 million barrels per day. Today, its production level is half that amount at around 6 million barrels per day. The combination of low domestic prices, non-payments by consumers, high taxation of producers, and an uncertain fiscal and legal regime, has caused a collapse in drilling activity and new field development. Oil production has probably bottomed out and will slowly begin to rise, but it will not reach its high production levels of the 1980s until well into the next century. Another potential supplier of oil to world markets in the area of the old Soviet Union is the Central Asian and Caspian Sea region. Oil reserves in this area represent a major new source of oil for the 21st century. Before this becomes a reality, however, the oil needs to be transported to markets in Western Europe and Asia through a volatile belt of countries and districts. There is much uncertainty surrounding the development of adequate pipeline routes to consumer markets.[5]

- Economic and Political Stability in the Middle East: Economic and political stability in the Persian Gulf region is an essential element of maintaining energy security. Each of the oil market disruptions of the 1970s, 1980s, and 1990s was linked to instability in the Gulf region. I certainly hope peace and economic stability reign throughout the region, but we should not count on it.

D. Path Toward a Sustainable Future?

The world is steadily heading toward greater reliance on the Persian Gulf for its principal energy resource—oil. Indeed almost half of the world's oil may have to come from this volatile region within the next 15 years.

The region is poised to undergo significant change over the next decade. The aging leaders, the increasingly apparent dissatisfaction on the part of youthful and frustrated populations, and the growing assertiveness of movements and ideologies that contest the legitimacy of aging monarchies and civilian dictatorships all suggest that the region is ripe for major political upheavals.

[5] If pipelines are built according to plan, it is projected that oil exports from the Caspian Sea could be as high as 700,000 barrels per day beginning in 1997.

Against this backdrop, prudent policymakers should be asking themselves several questions:

- Are we maintaining a well-balanced energy portfolio—one that will help insulate us from the effects of another oil shock?
- What political/military options do we have in responding to a crisis in the Persian Gulf?
- What would be the costs, in terms of economics and national security, of another major oil shock?
- Is our present national security policy sustainable?

Some people may say that my perspectives on rising dependence on the Persian Gulf are overly pessimistic. However, I like to point out that in the field of national security, we never plan for good news.

PART III:

MEDIUM TO LONG-TERM ENVIRONMENTAL CHALLENGES

Our analysis of energy supply and demand patterns over the next 15 years points toward some troubling conclusions. The world, undergoing a profound economic expansion, is turning toward the most inexpensive energy sources available. This trend is not putting us on the right path toward a sustainable future, which so many governments, including our own, have made such a top priority.[6] Two of the most troubling trends are in the areas of national security and environmental quality—principal elements of any strategy for achieving sustainable development.

I have already alluded to what I think are the national security consequences of our continued reliance on oil from the volatile Persian Gulf. I believe we face the prospect of another oil market disruption within the next 3 to 5 years. Recall that the shortfall brought forth as a result of the Iranian revolution in 1979 involved only 5 percent of world oil supplies and lasted only three months. Yet it brought forth profound economic dislocation, both in industrialized countries, which plunged into deep recessions, and also for developing countries, which suffered severe balance of payments problems.

Expanded energy, both in the production and consumption phases, brings forth a host of environmental challenges—ones directly related to the theme of sustainable development. The two that I will touch upon briefly—acid deposition and global climate change—are the direct result of our use of fossil fuels.

A. Acid Deposition

Acid deposition, which first became a major concern in the highly industrialized regions of Europe and North America during the 1970s and 1980s, is beginning to become evident in many areas of East Asia—especially along the southern coast of China, the Korean peninsula, and Japan. Available monitoring shows that the acidity of rainfall has been rising dramatically in some areas of the region.

If counter measures are not taken, acid deposition in many areas will increase by more than a factor of five and exceed the levels observed in the most polluted

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[6] The term "sustainable development" has become one of the most widely used environmental and political concepts over the past several years. It first appeared in 1987 when the World Commission on Environment and Development (commonly referred to as the Bruntland Commission) released its report, *Our Common Future*. Sustainable development was defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

areas in Central and Eastern Europe.[7] Table 1 shows the current and projected emissions of sulfur dioxide for Europe, North America and Asia. The total projected sulfur dioxide emissions for Asian countries in 2000 and 2010 far exceed North America and Europe combined.

Figure 6: Current and Projected Sulfur Dioxide Emissions by Region (million metric tons)

Region	1990	2000	2010
Europe	38.0	22.0	14.0
North America	21.0	15.0	14.0
Asia	34.0	53.0	78.0
China	22.0	34.0	48.0
India	4.5	6.6	10.9
Other	7.5	12.4	19.1

Source: RAINS-ASIA Program.

B. Global Climate Change

Although uncertainty surrounds the theory of global climate change (regarding the extent and speed of such change, its overall effects and regional distribution, and the cost and effectiveness of efforts to prevent, slow down, or adapt to change), the magnitude of the risk led more than 150 countries to sign the Framework Convention on Climate Change (the Rio Convention) in 1992.

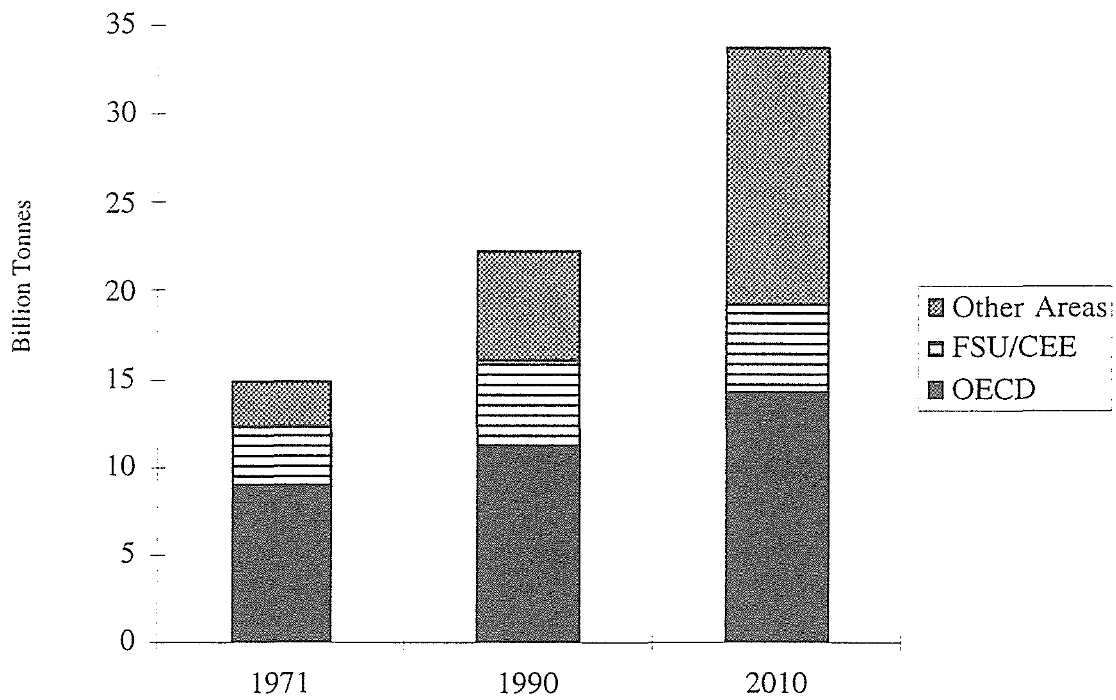
Despite the fact that political leaders in OECD countries have made commitments to stabilize their greenhouse gas emissions (at 1990 levels) by 2010, these commitments will not be achieved. The necessary energy policies to meet these targets are not being implemented. In fact, our GEMS Model/IEA projections demonstrated in Figure 7, illustrate that energy-related carbon dioxide emissions in 2010 will be over 30 percent higher than the 1990 level.

If the issue of global climate change is to be taken seriously over the long-term, a fundamental change will have to be made in the global energy structure, with

[7] Wes Foel et al, *RAINS-ASIA: An Assessment Model for Air Pollution in Asia*, Report on the World Bank Sponsored Project: "Acid Rain and Emission Reductions in Asia" (Washington, DC: World Bank, 1995). Some experts have noted that acid deposition could impact China's agricultural productivity, threatening to turn China into a net importer of rice in the next century.

increased reliance on non-fossil fuels such as nuclear and renewable energy sources.

Figure 7: World Carbon Dioxide Emissions



Source: GEMS Global Energy Supply and Demand Model and IEA.

We have seen that our path to the twenty-first century is one that is becoming increasingly reliant on fossil fuels. This reliance on fossil fuels raises significant energy security and environmental challenges—ones that would seem to be in direct conflict with our goal of sustainable development.

PART IV:

ENERGY SCENARIOS—FIFTY YEARS AHEAD

This past fall, I participated in a seminar organized by Dr. Jack Gibbons, the President Clinton's Chief Science and Technology Advisor, and Director of the White House Office of Science and Technology Policy. Dr. Gibbons was kind enough to invite me to the White House to provide him and his senior staff with an overview of our Trilateral Commission report.

Dr. Gibbons made several interesting comments at our meeting, including his assessment how we should examine our long-term energy future—the period 2010 to 2050. Dr. Gibbons pointed out that in examining long-term energy supply and demand, we first need to admit that there will be no "silver bullet" that will solve all our problems. Our energy solution, he noted, will involve several different technologies, including greater penetration of renewables,[8] more energy efficiency and better conservation, expanded use of clean-burning natural gas, and advanced nuclear energy technologies.

He said that if we want to see what type of role nuclear power will play, let us first try to determine the contribution of other energy sources and technologies. How much energy will renewables and natural gas be able to provide? Will greater energy efficiency and more conservation lead to reduced total energy demand? What type of transportation sector will be in place—fossil fuel-based or reliant on alternative energy sources (electrical powered vehicles)? Then, he stated, we will have a better idea of the need for nuclear energy—what amount of nuclear energy will be need to fill the gap?

Dr. Gibbons' observations are important and we were challenged to estimate the fuels requirements of a sustainable development future, including the range required of "clean and sustainable fuels" such as natural gas, renewables, nuclear power and greater energy efficiency.

A. Factors Driving Long-Term Energy Demand

This afternoon I would like build on Dr. Gibbon's remarks and present to you two different long-term energy scenarios that have we have generated from the GEMS Model. The two cases are:

- Business as Usual: relies on fossil fuels to provide the majority of our energy resources. In other words, a continuation of present policies.

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[8] Included as renewable energy technologies are: hydro, solid biomass, photovoltaic cells, wind power, geothermal, passive solar, and hydrogen.

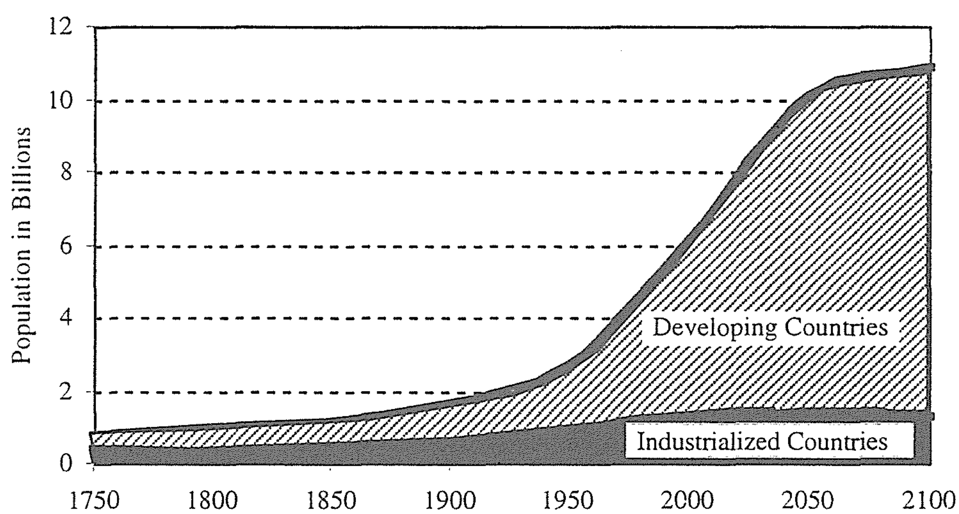
- Sustainable Growth: enhances the role of renewables, natural gas, and nuclear, and includes improvements in energy efficiency. In other words, a digression from fossil fuels.

In assessing long-term energy supply and demand futures, there are a number of factors which could affect long-term energy supply and demand, and I have tried to take these into account in building our projections.

In making our estimates for economic growth, we realize that there will be more rapid economic growth in some periods and much lower growth during others. Consequently, our economic growth for the 50 year period is 2.4 percent. This is about the average economic growth of the last 50 years.

Population growth will be another influential factor—especially the increasing urbanization of the world population. Our estimate for population growth over the next 50 years is approximately 1.7 percent, which is considerably lower than the average growth rate of 2.1 percent from 1971 to 1992. As demonstrated in Figure 8, even with low economic growth rate expectations, the world's population could almost double in the next 50 years.[9] We use the same estimates of economic and population growth in both scenario cases.

Figure 8: World Population Growth (1750-2100)



Source: World Bank.

[9] By 2025, the world population is projected to total 8.3 billion people, or about 45 percent more than the current estimated population of 5.7 billion. By 2050, world population projections reach 10 billion.

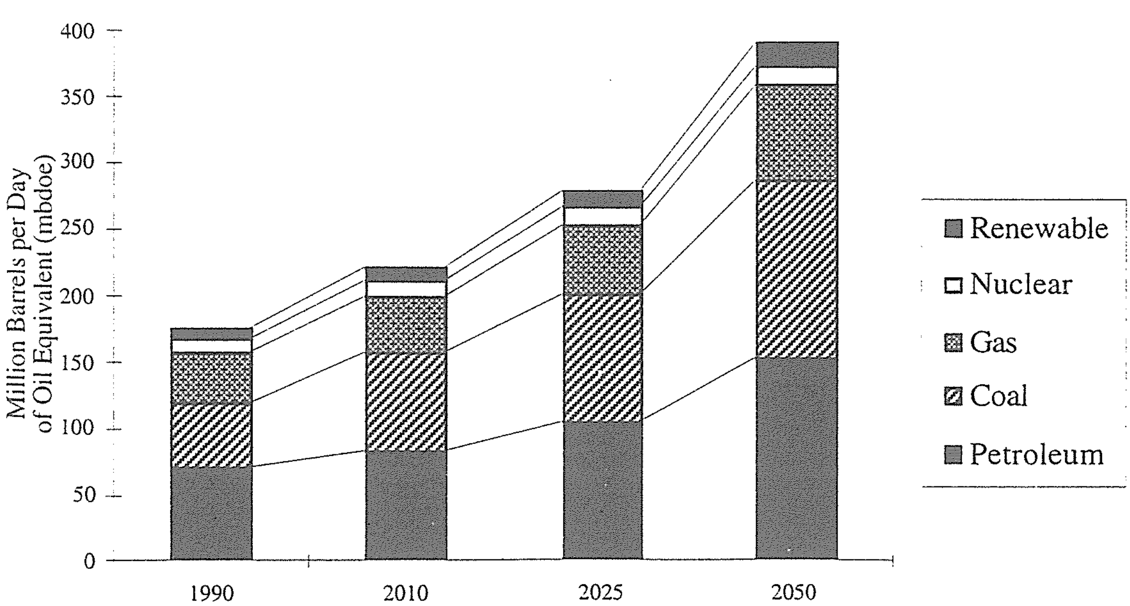
B. Business as Usual

First, let me discuss the business as usual strategy, which is based on a continuation of present policies and market conditions. Our assumptions for business as usual are:

- Continued reliance on oil in the transportation sector.
- Continued reliance on coal for electrical generation, especially in countries like China and India.
- Continued progress in energy efficiency in the transport, industry, and residential sectors.
- Continued growth in use of natural gas, including development of long distance pipelines.
- Continued increase in use of renewables, but no serious market penetration.
- Continued decline in nuclear energy generating capacity in OECD Europe and North America, but expansion of generating capacity in Asia.

With what type of energy future does this present us? As demonstrated by Figure 9, it is one in which we continue to use enormous amounts of fossil fuels—especially oil and coal. I don't think this type of future is sustainable, especially from a national security and environmental quality perspective.

Figure 9: World Primary Energy Demand by Fuel (1990-2050) -- Business As Usual



Source: GEMS Global Energy Supply and Demand Model.

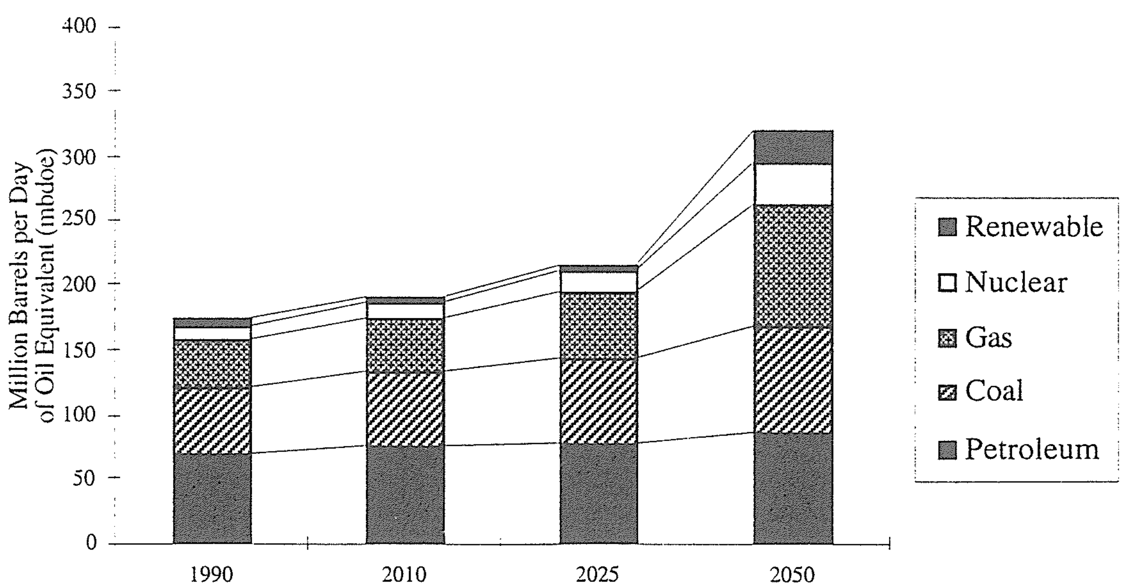
C. Sustainable Growth

That is why we take a hard look at our second scenario—sustainable growth—and ask, what must be done today to achieve a sustainable future? Given our huge energy supply and demand matrix, we try to force the model to give us results which are sustainable. Our principal assumptions for sustainable growth are:

- Improvements in energy efficiency and conservation.
- Growth in role of renewables in electricity generation sector.
- Augmentation of natural gas in transport, industrial, commercial, and electrical generation sectors.
- Expansion in nuclear generating capacity—more than threefold by 2050.
- Decline in use of oil and coal (as a percentage of total energy demand) in all sectors. Oil and coal production does not exceed 20 percent of production rates in 2010.
- Increase in use of electric vehicles in transportation sector (30 percent market share by 2050).

Figure 10 illustrates our projections for the sustainable growth scenario.

Figure 10: World Primary Energy Demand by Fuel (1990-2050) -- Sustainable Growth



Source: GEMS Global Energy Supply and Demand Model.

What does this energy projection tell us about our future? We can see from the sustainable growth scenario projection that fossil fuels still form a significant part of our energy portfolio, but far less than was apparent in the case of business as usual. Clean burning natural gas becomes the most important fossil fuel. We also see that renewables assume an important part in our energy supply picture.

What about nuclear power? Even with nuclear power only slightly increasing its percentage share of total electricity generated (from approximately 16 percent in 1990 to 20 percent in 2050), we see that nuclear energy generating capacity will have to increase about three-fold—from 325 GWe in 1990 to over 958 GWe in 2050.

This conclusion will not come as a surprise to this audience. What often surprises me is why environmental groups, so concerned about global climate change and acid deposition, do not embrace the nuclear energy option, a key element in any strategy designed to achieve sustainable development. Our sustainable growth scenario does not assume that nuclear energy will be the silver bullet that will overcome the energy challenges of the future. We are only assuming its role is slightly increased; yet, under this scenario, there would have to be an almost three-fold increase in nuclear generating capacity.

I think our snapshot of possible long-term energy supply and demand scenarios tells us that we have to maintain a well balanced portfolio of energy sources. It will be important to continue research and development on promising renewable technologies, especially biomass and photovoltaics. Natural gas we see as the fast growing energy source, largely because of its clean-burning attributes and availability. But this will require huge investments in natural gas infrastructure projects to get the gas to markets. We also underline the necessity of improving energy efficiency and promoting more conservation. Finally, we see nuclear power continuing to play a vital role in the electrical generation sector.

Part V:

Nuclear Power and the Importance of the Japanese Nuclear Energy Program

We have clearly seen from our last projections the importance of maintaining a balanced energy portfolio. In the case of business as usual, our future is dominated by oil and coal, both of which raise serious energy security and environmental quality problems. This future is clearly not sustainable.

This leaves us with our second case—sustainable growth. If we are to achieve this future, we need a well balanced energy portfolio, one that includes a strong role for natural gas, renewables, and nuclear.

A. Short-Term Challenges

If nuclear power is to play a part in our sustainable growth scenario—which projects a threefold increase in nuclear generating capacity—there are several short-term challenges that it must overcome. These are:

- Finding a solution to the problem of long-term storage of waste.
- Ensuring that nuclear energy is economically viable.
- Maintaining a high safety record, particularly in the former Soviet Union and rapidly industrializing countries.
- Meeting non-proliferation objectives.

The single largest challenge facing the nuclear power industry in the United States, and I believe the world, is the problem of long-term storage of spent nuclear fuel and other high-level radioactive wastes from commercial nuclear power installations. If this challenge is not overcome, the future of nuclear energy in this country will be in peril. We must continue our efforts and funding for the completion and siting of the permanent waste depository at Yucca Mountain.

Internationally, we should seek not only individual nation sites, but also consider the concept of an international monitored retrievable storage site (IMRSS), which would enable us to share expertise and expenses; and meet economic, non-proliferation, environmental and safety concerns.

The economics of nuclear energy, compared with other energy choices, will determine whether or not the United States will replace the existing generation of nuclear power plants. In order to improve the economics of nuclear energy, we need to improve the regulatory environment. In Japan, it takes about 5 to 7 years to complete a plant. In this country, it can often take more than 10 years.

The Nuclear Regulatory Commission has made important steps in streamlining licensing procedures and expediting the licensing process for pre-approved standard designs. These efforts at streamlining our burdensome regulatory environment must continue. Many still believe that even with regulatory reforms, the cost of nuclear energy is still much too high. However, I like to view the economics of nuclear energy from a national security perspective—one that factors in the externalities of fossil fuels.

For example, although oil may appear inexpensive at $20 to $25 per barrel, there are many costs which are not factored into the price, such as the cost of maintaining a military force ready to intervene at a moments notice in the Persian Gulf.

Coal too is cheap. But what about its social costs—specifically, its impact on the environment? What if we were to include in the pricing structure for fossil fuels the potential ramifications of global climate change?

Nuclear energy is the only energy form in which all factors are inputted into its cost—from enrichment of natural uranium to the disposal of waste and decommissioning of nuclear plants.[10]

I like to point out that electric utilities in Japan are criticized for their expensive electricity. Global competitors such as Toyota and Fujitsu might argue that the high cost of electricity in Japan, brought about in part due to new construction of nuclear power plants, may hinder their economic competitiveness. And looking only at the electricity sector, they may be right. But think of Ford and IBM. They may pay less for electricity, but they, indeed all citizens and companies, pay a tremendous premium to maintain a $300 billion per year defense budget. We all pay for energy security. It just comes out of different pockets. Let me say, however, that Toyota does benefit by U.S. troops stationed in the Gulf. I would also argue that Ford and IBM will benefit in the long-run by improvements in the Japanese nuclear industry, which can at a later date be made available to U.S. and European markets, when we do return to the nuclear option.

Over the past decade, operational safety of nuclear plants in OECD countries has been excellent. We need to continue this strong record of high safety standards. But maintaining our high standards of safety is not good enough. We need to ensure, to the best of our ability, that all countries operating nuclear plants meet high safety standards.

Safety of commercial nuclear power plants in the former Soviet Union is of primary concern. Another Chernobyl-scale accident would seriously endanger the future of nuclear energy world-wide. Last April, the G-7 held a special

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[10] This is not the case with any of the fossil fuels. We do not include the cost of the externalities of fossil fuel use (whether they be national security or environmental) in our price calculations.

Nuclear Safety Summit in Moscow. The Summit recognized the need for safety and security-related technical (and possible financial) assistance.

Plans to develop and/or expand nuclear energy programs in China, South Korea, Taiwan, and other rapidly industrializing countries need to be monitored carefully. A culture of safety and accountability, as is present in OECD countries, needs to be impressed upon these countries. This is a role which Japan, which I believe has the most advanced commercial nuclear energy program in the world, needs to play. Japan has an outstanding record in safety and accountability. It should take the lead in promoting these same standards among its Asian neighbors.

Non-proliferation concerns will have a direct impact on nuclear energy's future. Non-proliferation challenges are much more varied and complex than they were during the height of the Cold War—a time when two nations stood poised with nuclear weapons ready to destroy one another. Today's threat from nuclear weapons is more complex and much more difficult to identify. While the United States and Russia maintain their nuclear arsenals (along with the other declared nuclear weapon states), other countries, such as Iran, North Korea, and Iraq seek to develop nuclear weapons.

What can be done to reduce the threat of the proliferation of nuclear weapons? First, the role of the International Atomic Energy Agency (IAEA) needs to be strengthened. The IAEA has played a vital role in reducing the danger of nuclear weapons development in Iraq and North Korea. Other challenges await. We need to ensure that it has the proper resources to carry out its monitoring functions.

Second, we need to continue our close cooperation with our Japanese and European colleagues. The foundation of this cooperation is both the U.S.-Japan Nuclear Cooperation Agreement and the U.S.-EURATOM Agreement. I applaud Ambassador Kennedy's efforts in negotiating the U.S.-Japan agreement and was delighted to see the U.S.-EURATOM agreement recently come into force. We need to work closely with our European and Japanese allies. As part of this partnership, we should respect and support their decisions to reprocess spent nuclear fuel. Japan and Europe view reprocessing as an integral part of their national energy policies. Instead of worrying about their reprocessing programs, we should be working with them in ensuring the safe and proliferation-resistant development of nuclear power in other parts of the world.

These are tough challenges, but let me say that they are no tougher than the national security, energy security and environmental problems associated with other alternatives.

B. Japan's Nuclear Energy Program

It is important to not only focus on the challenges of nuclear power, but also to look at its successes and opportunities. In this respect, I would like to say a few words regarding the success of the Japanese nuclear energy program and your efforts at long-term energy planning.

As a national security advocate, I understand and support the reasoning behind Japan's decision to make nuclear energy one of its principal energy resources in the next century. You have the world's second largest economy, yet has no indigenous energy resources. Oil, which accounts for over 50 percent of its primary energy supply, is almost 100 percent imported—70 percent of which comes from the Persian Gulf.

In typical Japanese fashion, you are undertaking a long-term nuclear energy strategy—with the goal of developing a fully closed nuclear fuel cycle. This long-term strategy is being carried out with future generations in mind, with the objective of securing for them a safe, sustainable, reliable, and environmentally sensitive fuel source in the twenty-first century. As with any new technology, the costs are high, but so is the cost of maintaining a military presence in the Gulf region to secure oil for America and the world. As stated in our Trilateral Commission report, Japan's long-term nuclear energy program is its contribution to maintaining our global energy security.

Many of you maybe aware that the Council on Foreign Relations, in close cooperation with the Japan Atomic Industrial Forum, has established an Energy Security Group in Washington. We meet on average every two months and discuss a wide range of energy security issues facing both the United States and Japan. In fact, just last week, at our April meeting, we greatly benefited by having two excellent speakers from Japan. Mr. Tomihiro Taniguichi, the Deputy Director of the Agency of Natural Resources and Energy at MITI gave a thorough overview of the Japanese nuclear energy policy and the key role nuclear plays in achieving the three objectives of Japan's overall energy program: economic growth, energy security, and environmental protection.

Following Mr. Taniguichi's remarks, Professor Shunsuke Kondo of Tokyo University gave a very interesting talk on recent efforts in Japan aimed at improving the dialogue among government, industry, and local communities in planning for future nuclear developments. Our American participants, which included Kyle Simpson—Secretary of Energy Pena's senior advisor and former Secretary of Defense under President Kennedy, Robert McNamara, noted that United States also faces public acceptance challenges over implementing energy policy.

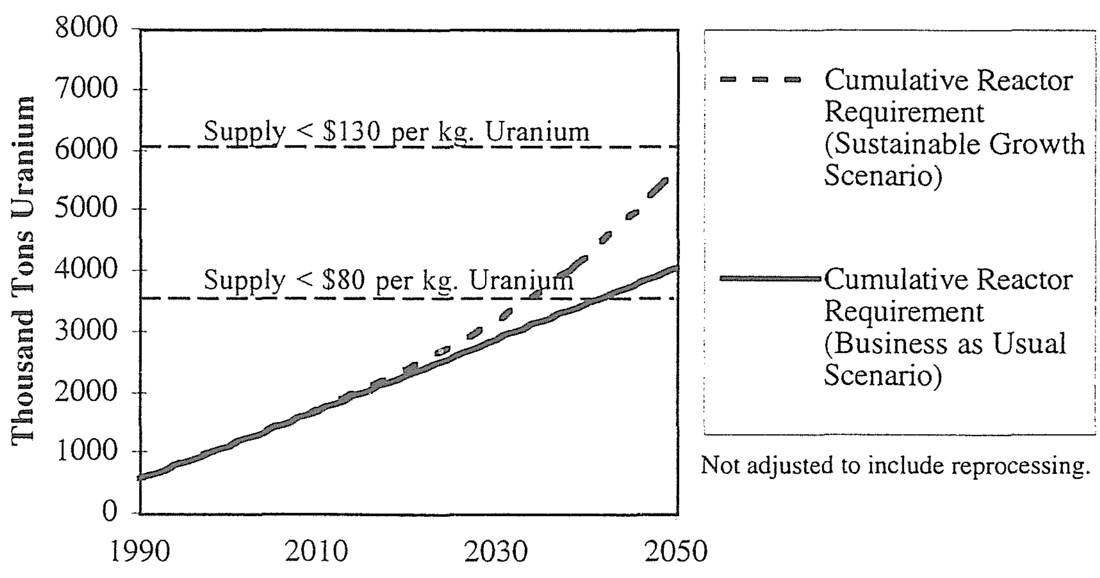
C. Medium to Long-Term Nuclear Energy Technologies

Discussion of Japan's nuclear energy program brings me to the issue of continuing our development of a number of advanced nuclear technologies—a discussion that is best left to the technical experts at this conference. Nevertheless, I still would like to make several brief comments from a layperson's perspective. If nuclear power is to play a dominant role in the 21st century, research and development of advanced nuclear reactors and technologies must continue—just as is the case with any other energy technology. One such advanced nuclear technology under development in Japan, and from what I understand, one that will be commercialized toward the end of this century, is the use of mixed-oxide (MOX) fuel.

Several European countries have already a number of years of experience in using MOX in commercial reactors. Japan's objective of using MOX fuel toward the end of the century is at the core of its energy security strategy. From the perspective of maximizing national energy resources, it is not enough for Japan to replace oil with nuclear power. It is also important to make the nuclear power program as self-sufficient as possible by reprocessing spent fuel and recycling plutonium into MOX fuel and using it in commercial reactors. I think reprocessing is a viable technological option and one that makes not only sense from a national security perspective, but also from an economic perspective over the medium to long-term.

Although uranium resources are currently abundant and inexpensive, which raises questions about the economics of reprocessing and long-term research on the breeder reactor technology, the situation could change. If we are to achieve our sustainable growth scenario—whereby North America and OECD Europe return to nuclear energy for reasons of economic, national and environmental security reprocessing will not be a luxury, but a necessity. Part of our GEMS Model includes a relatively straight forward nuclear fuel cycle analysis, which can project natural uranium civilian reactor requirements out to 2050 and compare these figures with current known uranium resources.

Figure 11: Cumulative Civilian Reactor Uranium Demand Compared to Known Uranium Resources



Source: GEMS Global Energy Supply and Demand Model

Figure 8 compares the current known supply of natural uranium to aggregate consumption by civilian nuclear power reactors. The current known supply of uranium recoverable for under $80 per kilogram is 3,800,000 tons according to the Uranium Institute. Total natural uranium resources minable for under $130 per kilogram is 6,200,00 tons. Cumulative demand for uranium projected by the GEMS Model show that the cheaper sources of natural uranium (under $80 per kilogram) will be exhausted by the year 2045 in the business as usual scenario, and by 2036 in the sustainable growth scenario. After this time, the burning of reprocessed uranium in the form of MOX fuel will become cost efficient. More noticeably, the increased use of nuclear fuel in the sustainable growth scenario results in a rapid increase in uranium prices after the year 2030, approaching $130 per kilogram by the year 2050.

Part VI:

Conclusions

This afternoon I have presented a broad overview of a number of the energy security and environmental challenges facing the world. Some of these are short-term in nature, while others are more medium to long-term in nature.

In the short-term, the most daunting energy security challenge is our increasing reliance on the volatile Persian Gulf region. Reducing dependence will be difficult, especially for the rapidly industrializing nations of Asia and Japan who have little alternative but to purchase Middle East oil. In fact, by 2010 Asia's import dependency on the Persian Gulf will rise to 95 percent.

This emerging dependence underlines the importance of building oil stocks in non-OECD nations, such as China. Stocks can be a vital resource in the event of a sudden supply disruption. Furthermore, it reinforces the need for the United States to maintain its active military presence in the Gulf region—protecting vital sea lanes and ensuring stability in Saudi Arabia and other Gulf states.

As we look to the medium-to-long term, faced with energy projections that indicate continued reliance on fossil fuels, a different type of energy-related challenge emerges—the environment. In Asia, the most acute problem in the medium-term will be acid rain, especially in the southern parts of China, the Korean peninsula, and Japan. Globally, the challenge will be climate change.

These emerging energy security and environmental challenges clearly demonstrate that we need to shift our global energy system away from fossil fuels and toward cleaner burning and renewable energy resources.

This cannot be achieved overnight, but will take several decades. Japan can play a key role, through its nuclear energy program, in leading the world toward a more sustainable energy system. Japan's role in developing advanced nuclear technologies in the twenty-first century will be much like that of the United States in the twentieth century when it protected the world's vital energy resource—oil.

Recent incidents at the Tokaimura waste reprocessing plant and Monju fast breeder reactor have shaken the Japanese public's confidence in nuclear power. While these incidents are serious, it is essential to point out to the Japanese public that no energy resource option is without its challenges. Oil—Japan's principal energy resource, comes from the volatile Middle East. Natural gas—while abundant, is often located far from markets and requires the construction of long-distance pipelines through politically sensitive regions and also requires expensive infrastructure development. Coal is inexpensive, but a direct contributor to the most challenge environmental issues of our time—acid rain and global climate change. Renewables, while attractive, are limited and unable to provide any significant amount of energy. As we conclude in our Trilateral

Commission report, nuclear power emerges as a key energy source in terms of achieving long-term sustainable development:

> *Nuclear energy has considerable appeal from the perspective of all three faces of energy security. If the energy security problem is vulnerability to disruptions in an emergency due to heavy dependence on imported oil from an unstable Middle East, nuclear power is an alternative energy source which can reduce dependence on imported oil. If the energy security problem is the long-term problem of sustainable development, given the global climate change implications of rising greenhouse gas emissions from the burning of fossil fuels, nuclear power emits no greenhouse gases or sulfur dioxide or nitrous oxides that create acid rain.*[11]

Last week, in an opinion editorial in the *Christian Science Monitor,* I underlined the importance of Japan's state-of-the-art nuclear energy program and stated that the Japanese nuclear power program:

> *. . . will provide U.S. and global planners with an important renewable source of power that will enable the inhabitants of the twenty-first century to grow and thrive as their oil-dependent ancestors of the twentieth century."*[12]

Responding to an article on global climate change which appeared in the *Wall Street Journal* in mid-March, I pointed out how Japan, the host nation of the upcoming Kyoto climate change conference, is a solid example of a nation with a sound energy policy and one which includes nuclear power as an important component:

> *Japan has recognized that the safe, expanded use of nuclear energy provides environmental benefits locally, regionally and globally on a source that other renewable fuels may never achieve. Locally, there is less pollution in Japan's cities and countryside. Regionally, there is less acid rain caused by power production in Japan. But, most importantly for the international community, with nuclear power production increasing at the expense of oil and/or coal, greenhouse gas emissions are greatly reduced.*[13]

While the future for nuclear power in Japan, and more broadly speaking, Asia, is bright, the situation in the United States is uncertain. Nevertheless, there have been several encouraging developments which suggest a more optimistic future. In his testimony before the Senate Energy and Natural Resource Committee in late January, then-Secretary of Energy designate, Frederico Pena, cited energy security as one of this top energy priorities and the need to "level the playing

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[11] *Maintaining Energy Security in a Global Context,* pg. 67.

[12] Please refer to appendix for a copy of Mr. Martin's opinion editorial in the *Christian Science Monitor.*

[13] Please refer to appendix for a copy of Mr. Martin's letter to the editor of the *Wall Street Journal.*

field" for nuclear power. Dr. Gibbons, President Clinton's top science advisor, has also noted the important role of nuclear power in the twenty-first century—viewing nuclear power as a integral part of a balanced energy portfolio. At our nation's leading national laboratory—the Los Alamos National Laboratory, and under the direction of lab Director, Dr. Sig Hecker, he and his scientists are conducting a long-term nuclear vision.

As we look to the future, energy will play a key role in determining the pace of our economic development and depending how and what type of energy resources we use, the quality of our environment. The energy security and environmental challenges we face should be viewed in a positive light—challenges that can be met. In overcoming these challenges, whether it is helping the Chinese develop a more efficient and cleaner burning energy system, encouraging the continued development of non-fossil fuels such as nuclear and renewables, or bringing over 100 nations together to discuss global climate change in Kyoto, energy can act as bridge to building a greater harmony among all nations.

APPENDIX A:

DESCRIPTION OF GEMS GLOBAL ENERGY SUPPLY AND DEMAND MODEL

The GEMS Model compiles energy statistics from the base year 1990[14] to develop energy demand projections for Canada, China, France, Germany, India, Japan, South Korea, Taiwan, the United Kingdom, and the United States. These projections are incorporated into the regional projections compiled for Africa, the former Soviet Union, Latin America, the Middle East, Non-OECD Asia, Non-OECD Europe, OECD Europe, OECD North America, OECD Pacific and the OECD Total. The regional totals are aggregated in the world total. GEMS uses the standard energy supply/demand integration sheet used extensively by energy analysts around the world.

For this presentation, GEMS has developed two scenario cases: (1) "business as usual" and (2) "sustainable growth."[15] In the business as usual scenario, projections are based on current practices that rely heavily on oil for transport and coal for electrification—in other words, a continuation of present policies. It also accounts for continued progress in energy efficiency in the transport, industry, and residential sectors, and growth in use of natural gas, including development of long distance pipelines. It assumes that renewables make no serious market penetration. Nuclear energy generating capacity declines in North America and OECD Europe, but increases in East Asia. In the sustainable growth scenario, we assume vast improvements in energy conservation and efficiency; growth in the role of renewables in the electricity generation sector, and augmentation of natural gas use in the transport, industrial, commercial, and industrial sectors. Nuclear energy's role is slightly increased from today's level of generating approximately 17 percent of the world's electricity to generating about 20 percent of the world's electricity. We also assume that electric vehicles account for 30 percent of the market share in the transportation sector by 2050.

An important assumption of the GEMS model is the projected economic growth of each region and country through 2050. The economic growth assumptions are calculated from data available from the OECD Secretariat and the

[14] All projections are made from base-year statistics 1990, compiled from IEA publications: *Energy Statistics and Balances of Non-OECD Countries 1989-1990* (Paris) and *Energy Balances of OECD Countries 1990-1991* (Paris).

[15] The final energy demand total in 2050 under the sustainable growth scenario (approximately 330 million barrels per day oil equivalent) is lower than the final energy demand total under business as usual (approximately 380 million barrels per day oil equivalent) because of the assumed increases in energy efficiency and conservation under the sustainable growth case.

World Bank. The GEMS model, however, is generally more realistic about world economic growth than either of these two organizations. The average world economic growth from 1990 to 2050 estimated by the GEMS Model is 2.4 percent. Population growth will be an important determining factor for economic growth rates—especially the increasing trend of urbanization. Our estimates for population growth over the next 50 years are 1.7 percent, which is considerably lower than the average growth rate of 2.1 percent from 1971 to 1992.

The energy /GDP ratio is one of the most important assumptions made in the model. This ratio determines the energy intensity of an economy and represents an important distinction between rapidly industrializing (China and India) and industrialized (OECD) countries. Rapidly industrializing countries have a higher energy use per unit of GDP because their industries (steel and heavy manufacturing) are more energy-intensive. Industrialized countries have lower energy /GDP ratios because their industries (service industries) are less energy-intensive. This ratio is multiplied by the economic growth rate to determine the final energy demand growth rate. The GEMS Model takes into account that the energy efficiency of technologies used by developing countries is steadily improving. While they may not always adopt the most efficient technologies, the basic standard has risen dramatically over the last 15 to 20 years, allowing developing countries to leap-frog to more efficient energy technologies. Having the benefit of more efficient technologies will result in developing countries having lower energy/GDP ratios than currently industrialized countries at a similar earlier stage of development. The final demand growth rate is found by multiplying the estimated economic growth figure by the energy /GDP ratio. It is used to determine the growth of final energy demand for each region and country in GEMS. The sector demand shares by fuel for the transportation, industrial and commercial/residential sectors, are based on the 1990 IEA data. For each country and region, depending on the scenario, changes are made to the sector demand shares to show increased (or decreased) usage of oil, coal, natural gas, nuclear, and renewable energy sources in each sector over the 60 year period. Changes in the relative importance of the transportation, industrial, and commercial/residential sectors also illustrate changing energy needs for the countries and regions in the GEMS model.

APPENDIX B:

ASSUMPTIONS FOR BUSINESS AS USUAL AND SUSTAINABLE GROWTH SCENARIOS

WORLD

GROWTH ASSUMPTIONS		1990-2000	2000-2010	2010-2025	2025-2050		1990 [H1]	2000 [I1]	2010 [J1]	2025 [K1]	2050 [L1]
ECONOMIC GROWTH % [A2]		2.45	2.50	2.40	2.40	TRANSPORTATION FUEL MIX %					
ENERGY/GDP RATIO % [A3]		0.70	0.70	0.60	0.60	COAL [G3]	1.37	1.52	1.56	1.58	1.52
FINAL DEMAND GROWTH RATE % [A4]		1.72	1.75	1.44	1.44	PETROLEUM [G4]	96.63	96.49	95.29	94.28	92.16
						GAS [G5]	0.67	0.56	0.57	0.57	0.60
SUPPLY ASSUMPTIONS	1990	2000	2010	2025	2050	ELECTRICITY [G6]	1.34	1.42	2.58	3.57	5.72
INDIGENOUS PRODUCTION											
(millions metric tons of oil equivalent)						INDUSTRIAL FUEL MIX %					
COAL [A9]	2322.02	2716.39	3459.44	4497.14	6277.54	COAL [G9]	34.04	32.03	32.60	32.94	33.06
PETROLEUM [A10]	3236.25	3205.42	3800.47	4797.88	6995.88	PETROLEUM [G10]	22.79	31.40	30.92	30.72	30.79
GAS [A11]	1702.45	1603.11	1901.38	2368.71	3293.82	GAS [G11]	24.43	19.64	18.71	17.80	16.47
NUCLEAR [A12]	515.39	521.35	545.75	654.29	670.71	ELECTRICITY [G12]	18.74	16.92	17.78	18.54	19.68
RENEWABLES [A13]	248.03	336.54	468.44	525.22	800.66						
NUCLEAR CAPACITY (GWe) [A14]	325.83	329.60	345.03	361.94	349.20	COMMERCIAL/RESIDENTIAL FUEL MIX %					
						COAL [G15]	18.36	18.80	18.39	17.55	16.50
EXPORTS/IMPORTS (NET) [A15]						PETROLEUM [G16]	20.49	21.14	21.42	22.49	24.36
COAL [A16]	-19.06	0.00	0.00	0.00	0.00	GAS [G17]	31.38	29.73	28.76	27.00	24.61
PETROLEUM [A17]	-175.60	0.00	0.00	0.00	0.00	ELECTRICITY [G18]	29.77	30.32	31.44	32.97	34.54
GAS [A18]	-21.76	0.00	0.00	0.00	0.00						
ELECTRICITY [A19]	-0.60	0.00	0.00	0.00	0.00	ELECTRICAL GENERATION SHARE %					
						COAL [G21]	39.82	43.44	45.59	46.66	46.08
SECTOR DEMAND SHARES %						PETROLEUM [G22]	15.87	14.57	14.17	15.02	17.14
TRANSPORTATION [A22]	27.45	28.00	28.00	28.00	28.00	GAS [G23]	20.80	18.13	17.94	18.49	19.23
INDUSTRIAL [A23]	47.15	47.92	47.95	48.49	47.35	NUCLEAR [G24]	15.87	14.50	12.00	11.00	8.00
COMMERCIAL/RESIDENTIAL [A24]	25.40	24.08	24.05	23.51	24.65	RENEWABLES [G25]	7.64	9.36	10.30	8.83	9.55

CASE SCENARIO: BUSINESS AS USUAL

WORLD

GROWTH ASSUMPTIONS		1990-2000	2000-2010	2010-2025	2025-2050		1990 [H1]	2000 [I1]	2010 [J1]	2025 [K1]	2050 [L1]
ECONOMIC GROWTH % [A2]		2.45	2.50	2.40	2.40	TRANSPORTATION FUEL MIX %					
ENERGY/GDP RATIO % [A3]		0.70	0.70	0.50	0.50	COAL [G3]	1.37	1.50	1.25	1.00	0.00
FINAL DEMAND GROWTH RATE % [A4]		1.72	1.75	1.20	1.20	PETROLEUM [G4]	96.63	97.00	96.00	85.00	60.00
						GAS [G5]	0.67	0.67	2.00	4.00	10.00
SUPPLY ASSUMPTIONS	1990	2000	2010	2025	2050	ELECTRICITY [G6]	1.34	0.83	3.50	10.00	30.00
INDIGENOUS PRODUCTION											
(millions metric tons of oil equivalent)						INDUSTRIAL FUEL MIX %					
COAL [A9]	2322.02	2274.30	2640.48	2977.95	3740.47	COAL [G9]	34.04	32.00	32.00	30.00	20.00
PETROLEUM [A10]	3236.25	2938.16	3438.07	3569.97	3925.42	PETROLEUM [G10]	22.79	24.00	25.00	22.00	18.00
GAS [A11]	1702.45	1697.27	1930.75	2418.81	4446.81	GAS [G11]	24.43	25.00	25.00	25.00	27.00
NUCLEAR [A12]	515.39	522.69	526.60	694.59	1515.86	ELECTRICITY [G12]	18.74	19.00	20.00	23.00	35.00
RENEWABLES [A13]	248.03	137.88	150.46	255.90	1061.11						
NUCLEAR CAPACITY (GWe) [A14]	325.83	330.45	332.92	439.12	958.33	COMMERCIAL/RESIDENTIAL FUEL MIX %					
						COAL [G15]	18.36	18.50	18.50	15.00	10.00
EXPORTS/IMPORTS (NET) [A15]						PETROLEUM [G16]	20.49	21.00	22.00	20.00	15.00
COAL [A16]	-19.06	0.00	0.00	0.00	0.00	GAS [G17]	31.38	30.50	29.50	28.50	35.00
PETROLEUM [A17]	-175.60	0.00	0.00	0.00	0.00	ELECTRICITY [G18]	29.77	30.00	30.00	36.50	40.00
GAS [A18]	-21.76	0.00	0.00	0.00	0.00						
ELECTRICITY [A19]	-0.60	0.00	0.00	0.00	0.00	ELECTRICAL GENERATION SHARE %					
						COAL [G21]	39.82	39.82	42.50	41.00	32.00
SECTOR DEMAND SHARES %						PETROLEUM [G22]	15.87	16.00	15.00	11.00	10.00
TRANSPORTATION [A22]	27.45	28.00	28.00	28.00	28.00	GAS [G23]	20.80	20.80	20.00	22.00	24.00
INDUSTRIAL [A23]	47.15	47.92	47.85	48.03	48.65	NUCLEAR [G24]	15.87	18.50	17.50	19.00	20.00
COMMERCIAL/RESIDENTIAL [A24]	25.40	24.08	24.15	23.97	23.35	RENEWABLES [G25]	7.64	4.88	5.00	7.00	14.00

CASE SCENARIO: SUSTAINABLE GROWTH

THE CHRISTIAN SCIENCE MONITOR

Monday, March 31, 1997

OPINION/ESSAYS

Nuclear Doubts Put US Out of Step on Global Warming

Japan, host to coming conference, sets the best example

By William F. Martin

BRITISH Environment Secretary John Gummer's recent remarks concerning the US's "profligate energy consumption" is the first volley in what will be nine contentious months leading up to a critical International conference on global climate change this December in Kyoto, Japan. Mr. Gummer's open criticism of the United States was followed by reports of disagreements among European Union environment ministers on targets for reducing greenhouse emissions – indicating just how difficult it will be to reach consensus by the end of the year.

Gummer is concerned that even the most aggressive action to cut the consumption of fossil fuels by relatively small countries, like Britain, will mean little if larger industrialized countries continue at current and growing rates of consumption. While economic giants, like the US and certain members of the European Union, continue to proceed slowly in agreeing to emission reductions, removal of barriers to world trade has ignited economic development and manufacturing all around the world. Growth in countries like China and India typically means increased reliance on the least expensive and most polluting sources of energy – oil and coal.

For America to be a leader in developing a global strategy on climate change it must reduce its own emissions and address a full range of renewable resources.

Both the threat of global climate change and the world's growing energy demands will force participants at the Kyoto conference, and the US in particular, to reevaluate dated positions on energy policy. Washington has some difficult realities to face. American energy policy, built on the cheap and abundant oil supplies of the 20th century, continues to project a relatively stable energy supply 50 years into the future.

This ignores, however, the far-reaching nature of issues raised by the specter of global climate change. An American view that the US might buy its way out of this dilemma through new global emissions trading agreements is shortsighted at best.

'Energy independence' outdated

We can no longer think of energy in terms of "energy independence" for solely the US. With population growing around the world, exploding sales of automobiles, and dramatic increases in electricity consumption, it will be critical to develop new nonpolluting, secure sources of energy in the coming millennium. For America to be a leader in developing a global strategy on climate change it must not only own up to its responsibilities to reduce emissions, but it must also address a full range of renewable resources.

The issues raised by environmental threats (not to mention economic and national security considerations) are leading many to recognize the need for a transition away from oil- and coal-based power sources. Industrialized countries are pursuing ways to reduce emissions – ranging from retrofitting plants with energy-efficient lighting to engaging the power of the free market through emissions trading schemes. Throughout the world calls are heard for a massive shift to renewable sources of energy like solar, wind, and nuclear power. The former options are relatively noncontroversial, but nuclear power, the most advanced renewable source of power, remains a lightning rod for many, especially in the US.

The glare of Three Mile Island

American attitudes towards nuclear power are much like the proverbial deer, caught this time in the headlights of Three Mile Island. Public discussions on nuclear power typically emphasize incidents of the past rather than focus on the present. Perhaps it is telling, then, that Japan, the host of the Kyoto conference and no stranger to the destructive potential of nuclear power, today offers a solid example of a national energy policy that deserves American support.

A critical component of Japan's plans for safely and sustainably meeting their energy needs is the expanded use of nuclear energy, providing environmental benefits locally, regionally, and globally. Locally, there is less pollution in Japan's cities and countryside. Regionally, there is less acid rain caused by power production in Japan. Globally, with nuclear power production increasing at the expense of oil and/or coal, greenhouse gas emissions are greatly reduced.

Also important, Japan's electric utilities continually incorporate technological advances, such as efforts to recycle (reprocess) spent nuclear fuel to ensure the most environmentally sensitive and efficient use of resources. By reprocessing spent nuclear fuel into mixed oxide (MOX) fuel, Japan maximizes use of uranium resources and is better able to manage nuclear waste.

As the United States prepares for Kyoto, it would do well to look to its host as one source of new thinking in addressing the policy conundrum of sustainable development. This term first appeared in 1987 when the World Commission on Environment and Development (known as the Brundland Commission) released its report, "Our Common Future." In that report, sustainable development was defined as, "meeting the needs of the present without compromising the ability of future generations to meet their own needs."

Japan's state-of-the-art use of nuclear energy will provide US and global planners with an important renewable source of power that will enable the inhabitants of the 21st century to grow and thrive as did their oil-dependent ancestors of the 20th century.

But the US, the originator of nuclear energy and once the industry leader, may have to take a back seat while other nations take the nuclear lead.

■ *William F. Martin served as deputy secretary of energy for President Reagan.*

THE WALL STREET JOURNAL WEDNESDAY, APRIL 2, 1997

Cool Views on Global Warming

An international conference on climate change, to be held in Kyoto, Japan, later this year is forcing the international community to grapple with a raft of contentious issues concerning the rising concentration of carbon dioxide and other greenhouse gases in the earth's atmosphere. Your column notes that whatever the scientific or political disagreements, economic experts have come to agree that "standing pat is not an option."

For its part, the U.S. is struggling to come to grips with a policy that sets limits on carbon gas emissions, but also provides flexibility. One area of flexibility it seems unwilling to address is the critical role nuclear power can play in ensuring that the energy needs of a growing world are met while global carbon emissions are reduced. When it comes to the proper role of nuclear energy, Americans seems stuck in the 1970s.

Yet the host of the conference on climate change, Japan, a nation more experienced than any other with the negative consequences of nuclear energy, is today a solid example of a sound national energy policy, which includes nuclear power as an important component. Japan has recognized that the safe, expanded use of nuclear energy provides environmental benefits locally, regionally and globally on a source that other renewable fuels may never achieve. Locally, there is less pollution in Japan's cities and the countryside. Regionally, there is less acid rain caused by power production in Japan. But, most important for the international community, with nuclear-power production increasing at the expense of oil and/or coal, greenhouse gas emissions are greatly reduced.

WILLIAM F. MARTIN

Washington

(Mr. Martin served as deputy secretary of energy for President Reagan.)

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気候変動枠組み条約・京都会議（UN FCCC COP3）が原子力開発に及ぼす影響

経済協力開発機構・国際エネルギー機関（ＯＥＣＤ/ＩＥＡ）
長期協力・政策分析局長
ジャン-マリー・ブデール

序論：公正かつ中立的な仲裁機関としてのＩＥＡ

第１部―エネルギー枠組みの設定
- ３つのエネルギー関連サービス：電気、動力、熱
- 電力部門の必要容量から見た影響
- 政治・経済の影響の受けやすさから見た過去の教訓

第２部―気候変動に関する交渉
- ベルリン・マンデート：ＱＥＬＲＯｓ（定量的排出制限および削減目標）
- 石炭価格の感受性：どのエネルギー関連サービスが影響を受けるか
- 妥協可能な全世界排出許可システムの中で炭素値をどのように設定するか

第３部―原子力の政治的課題
- 供給の確保：多様化と国内産供給の役割
- 制度的枠組み：原子力と再生可能エネルギーにとっての公平な競争の場
- 民生用原子力技術の取引を可能にするための国際協定、原子力をめぐる阻害要因への対処の必要性

結論：持続可能な開発にむけた世界的な課題

CLIMATE CHANGE AND NUCLEAR POWER'S FUTURE

MR. JEAN-MARIE BOURDAIRE
and
MR. JOHN PAFFENBARGER

INTERNATIONAL ENERGY AGENCY
FRANCE

Conference Paper

Presented at the Annual Conference of the Japan Atomic Industrial Forum

Tokyo, Japan
9-11 April 1997

Climate Change and Nuclear Power's Future

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Presented at the Annual Conference of the Japan Atomic Industrial Forum
Tokyo, Japan, 9-11 April 1997

ABSTRACT

The potential impact of energy use on the earth's climate is a subject of increasing international importance. The meeting of the parties to the Framework Convention on Climate Change taking place in Kyoto, Japan in December 1997 will attempt to set out a real international plan for curbing emissions of greenhouse gases. In a general sense, and regardless of the specific outcome of the Kyoto meeting, if emissions of carbon dioxide are to be curbed there must be some recognition of the value of producing less carbon dioxide from energy use. Market oriented plans using tradeable permits or offsets are possible means of recognising this value.

Workable policies to curb carbon dioxide emissions from energy consumption must take into account the sectoral characteristics of energy use. This paper summarises sectoral and regional patterns of energy use and identifies the potentially important role of power generation and nuclear power generation in providing opportunities to reduce carbon dioxide production. Development of a carbon value would change the results of interfuel competition, tending to favour lighter (less carbon intensive) fossil fuels and particularly natural gas. In the long term, power plants based on nuclear and renewable sources of energy could be favoured because, in contrast to fossil-fuelled power plants, they are unaffected by any potential carbon value. Nuclear power would provide a limit to carbon value by providing a large source of carbon dioxide emissions reductions. Still, there are a number of policy constraints on nuclear power which would have to be loosened before it could play a significant role contributing to future energy supplies. First among them is the public willingness to accept new nuclear power plants, or even an extension of the lifetimes of currently operating plants. Solving the political problem of what to do with spent nuclear fuel is a key element of this. Plant designs that are seen to be safer than current plants also present a technical step in the right direction. In the international context, a key issue is ensuring that any expansion of civilian nuclear power does not lead to proliferation of nuclear weapons. The desire to reduce carbon dioxide emissions will not lead to greater use of nuclear power, even if it may be an economic solution, if some of the non-economic impediments to its use are not removed in the coming years.

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Climate Change and Nuclear Power's Future

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Presented at the Annual Conference of the Japan Atomic Industrial Forum
Tokyo, Japan, 9-11 April 1997

This December, in Kyoto, Japan, the Conference of the Parties to the Framework Convention on Climate Change will meet to try to establish a real international plan to curb emissions of greenhouse gases. Past limits on greenhouse gas emissions have been non-binding and will have been met in only a few countries. If the Kyoto conference does result in agreement on how to restrain the growth in greenhouse gases, the power generation sector will become involved in its implementation because of power's large contribution to carbon dioxide emissions. Power generators could be asked to provide the same amount of electricity while producing less carbon dioxide. This potential requirement to reduce the "carbon intensity" of power generation would erode the competitive position of coal- and oil-fired power generation compared to power generation using natural gas. In the long term, it could make power generation from all fossil fuels less competitive compared to to nuclear and renewable sources of electricity. This paper explores this idea further. First, the past patterns of energy use in the OECD are described. From these, the likely trends in electricity demand are outlined in the context of overall energy demand. Next, the potential impacts of a firm agreement at Kyoto are described, particularly the change in patterns of interfuel competition in energy-related services and electricity generation that would result from restrictions on carbon dioxide emissions. The paper concludes with the political challenges that face nuclear and which must be addressed before any potential economic advantage it may have due to climate change concerns could be realised.

As an international organisation without strong links to any single national point of view, yet one in close contact with the realities of energy policy and energy markets, the International Energy Agency (IEA) has a unique point of view in the climate change debate. The IEA is an authoritative source of national energy statistics and information for OECD countries, data upon which policy analyses must draw if their consequences are to be correctly understood. The IEA has been involved in the debate and discussion on climate change primarily by providing analyses of the potential effects of policies that might be implemented under the climate change convention.

Sectoral and Regional Patterns of Energy Use

What can past patterns of energy use tell us about our future appetite for energy? And what did the oil shocks of the 1970s reveal about the potential for changes in energy use patterns in response to price increases? There are several conclusions:

- the link between energy use and macroeconomic activity is strong. As national incomes have increased, energy use has increased in a nearly constant relationship.
- the oil price shocks increased energy prices substantially, but not enough or long enough to change this basic relationship.

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- there are, however, differences in patterns by end-uses. Stationary fossil fuel uses such as space heating and industrial uses have become less energy intensive since the 1970s, while electricity and transportation energy uses have remained in nearly constant relationships with incomes.

- there are also large differences by world region. The most important is the increasing share of energy consumption outside the OECD.

Sectoral Trends

The differences in energy use patterns by sector must be taken into account when considering the potential impact of climate change policies. Figure 1 shows the growth of energy use in relation to total gross domestic product in IEA countries from 1960 to 1994. Figure 2 shows the corresponding data for the world as a whole from 1971 to 1994. Total energy use has been categorised into the three end-use types mentioned above: stationary uses of energy, energy for transportation, and electricity. Each of these represents a demand for energy-related services rather than primary energy. Differences in the growth of energy use in each are evident.

The consumption of fossil fuels other than in electric power plants or in transportation, so-called stationary end-uses, includes industrial, agricultural, commercial, and residential energy uses. Of the three primary energy-related services, only stationary uses have not increased steadily with national income. This may be attributed to a number of factors, most importantly improved energy efficiency in industrial and residential uses, accentuated by a structural shift away from energy-intensive industry and corresponding increase in income share from services. Changes in energy use and location of steel production worldwide provide an example of these factors.[3] In many instances, this end-use involves the production of heat for space-heating or processing, where energy cost may represent a significant fraction of the total final service cost. In such cases, end-use demand is sensitive to the price of energy, and energy use decreased in response to price increases. Substitution of electricity for fossil fuels and changing patterns of residential energy use also account for part of the change in energy use in this sector.

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[3] See "The Impact of Structure, Technology and Location: Energy Demand in the Iron and Steel Sector," chapter 6 of the IEA "World Energy Outlook, 1996 Edition."

Figure 1. Evolution of IEA Energy Demand by Energy-Related Service 1960 to 1994

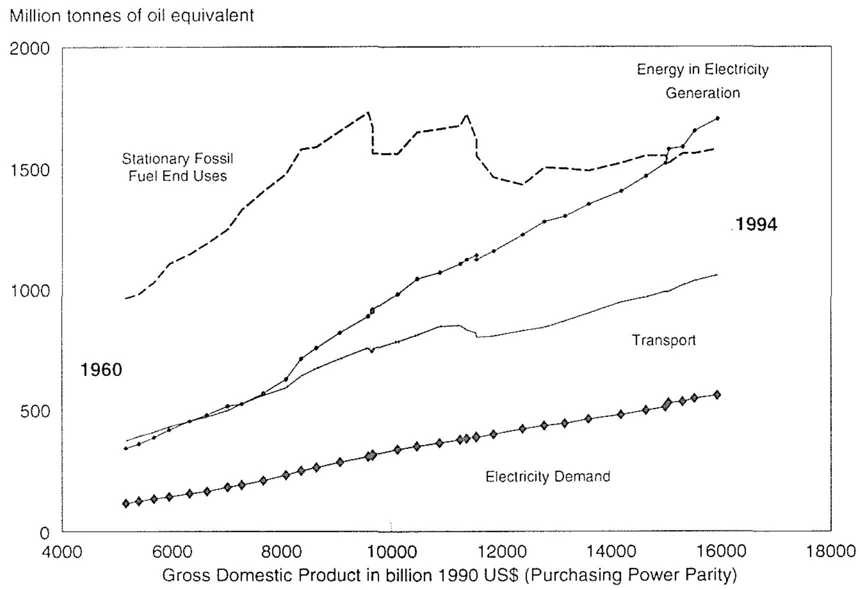
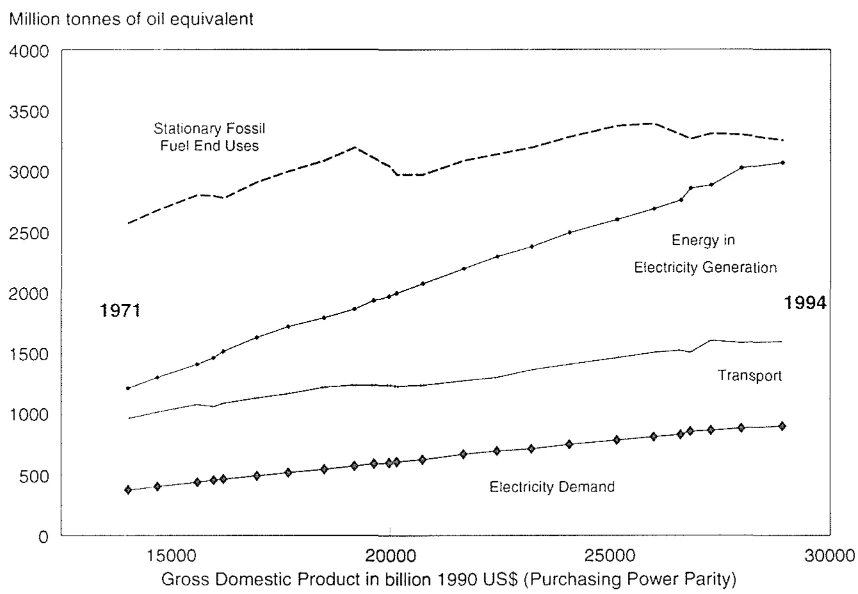


Figure 2. Evolution of World Energy Demand by Energy-Related Service



In contrast, transportation and electricity have increased steadily in line with incomes. Use of energy for transport has grown almost linearly with real income, although there was a small but noticeable readjustment after the 1979 oil supply disruption. Increasing levels of taxation on transportation fuels, promotion of mass transit, and increasing fuel efficiency of personal automobiles have not notably altered the gross pattern of energy use in transport. Perhaps the single most important reason explaining this is that there are few cost-effective substitutes for independent mobility in vehicles powered on petroleum fuels. Vehicles relying upon electricity or natural gas are today more expensive on a life-cycle basis and account for only a tiny fraction of overall energy use for transportation. Further, the price of transportation fuels, in real terms, has not risen significantly higher today its price before the oil shocks. In many countries it is in fact lower. In addition, fuel as a proportion of total automobile running costs is typically less than one third the cost of running a personal vehicle, so the impact of fuel price changes is diminished.

Electricity demand has also maintained a steady relationship with income. In nearly all end-uses, there has been a substitution of fossil fuels by electricity, driven by the cleanliness, ease-of-use, and competitive economics of electricity at the point of consumption. The steady penetration has been made possible by real electricity prices which on average have remained the same over the last decade. The period from 1975 to 1981 saw a period of increasing prices which reached 30% higher prices at its peak, and this was followed by a return to previous price levels by 1983. This period of increased electricity prices did not lower electricity intensity.

Installed power generation capacity has risen steadily to meet the growth in demand. In 1994 the OECD average stood at about 1.8 kW per capita or 100 kW per thousand 1990 dollars of gross domestic product. The latter has remained constant over past decades, as suggested by Figure 1. Acknowledging these figures, the IEA's World Energy Outlook projects installed capacity to increase by over 25% in the OECD and 120% in the rest of the world by 2010.

Regional Trends

The patterns of energy use vary not only by sector, but by region. The most important trend is that the OECD's share of world energy consumption is decreasing. The economies of OECD countries are growing relatively slowly compared to many developing country economies, particularly those of the dynamic Asian regions. Average growth in China, East Asia, and South Asia averaged 7.5% over the last decade, while in the rest of the world it averaged 2.4%. With rapid economic development comes rapid growth in energy consumption.

Somewhere between two-thirds and three-quarters of the growth in world primary energy demand over 1993 to 2010 is expected to take place outside the OECD. This is due not only to strong economic growth and industrial expansion, but also high population growth, increasing urbanisation, and substitution of traditional or non-commercial fuels by commercial energy. In many cases final energy demand is increasing from a relatively low level. Although final levels cannot be accurately known, the difference in demand for energy-related services between OECD and non-OECD countries can be expected to steadily decrease. For example, in many countries car ownership levels are increasing. Domestic electrical appliances are becoming more common.

The growth in energy demand for the power generation sector is likely to be based on coal to a much greater extent outside of OECD countries. Particularly in countries without access to pipeline natural gas or with relatively poorly developed natural gas supply infrastructure, coal-fired power generation is likely to dominate capacity additions. In the OECD, combined cycles fired on natural gas will account for the largest fraction of baseload capacity increase.

The regional differences in energy demand mean that patterns of growth in carbon dioxide emissions will differ by regions. They show the critical importance of non-OECD economies in eventual policies to curb emissions of greenhouse gases. As an example, emissions of carbon dioxide from China alone are expected increase as much as those from the whole of the OECD in the period 1990 to 2010.

Implications for Climate Change Policies

The trends described above suggest lessons for the debate on climate change policies. They are that:

- Any policy that significantly and permanently increases the price of fossil energy would, as the oil shocks, lead to changes in energy use that differ by the service it provides.

- Stationary fossil fuel use, primarily non-electricity industrial energy use and demand for heat, is responsive to short term price changes. In the longer term energy efficiency improvements and evolution towards a lower share of industrial demand have in the past had a large impact on energy intensity in this sector.

- Transport energy demand and electricity demand have shown a strong positive link with national incomes but are less sensitive to short-term energy price increases.

- Policies must involve all countries, not just OECD countries, because of the large growth in energy consumption outside of the OECD.

It is difficult to quantitatively predict potential effects of long-term fossil fuel price increases. Past prices of energy for transport and electricity have seen modest or no real long-term increases in many countries, and so do not necessarily provide a full basis for quantitative predictions of future energy demand. However, demand forboth energy-related services certainly depends upon price, among other factors, and increases in the service price for could be expected to reduce demand for them. Prices increases in transportation fuels would probably have little near-term impact on the fuel/technology choices for transportation, because today there are few economic alternatives to fossil-fuelled vehicles.

Unlike other energy-related services, electricity demand is not linked to a primary energy source at the point of use. That is, primary energy is transformed into electricity, today mainly in centralised facilities. This provides a flexibility in the energy supply system which allows primary energy sources to be changed while maintaining end-use equipment unchanged. The efficiency of electricity production may also change in response to fuel price changes, while end user prices are only indirectly affected. Shifts in the composition of the primary energy fuel mix for electricity generation do not require modifications to equipment for the ultimate service provided by electricity.

In electricity generation, the fuel mix has changed in order to minimise production cost as fuel prices change. This has been observed in practice, for example since the 1970s as the share of oil-fired power generation decreased and nuclear's share increased. The competitive economics of gas-fired power generation have led to its rapid increase in many countries. Thanks to such structural changes in power generation, increases in the final price of electricity have beeh moderated even as the economics of underlying interfuel competition have changed over time. This has tended to maintain the relationship of electricity consumption and national incomes.

Climate Change Policies and Their Potential Effects on Electricity

Parties to the Framework Convention on Climate Change have been discussing and debating policies to curb greenhouse gas emissions since 1992. Under the 1995 Berlin Mandate to the Convention, certain parties to the Convention are to develop "quantified emission limitation and reduction objectives" which would effectively limit or reduce national emissions of greenhouse gases to arrive at a globally sought target after 2000. Some parties have suggested that stabilisation of their emissions at 1990 levels will be acceptable, while others believe that cuts below these absolute levels of emissions will be required. The details of actual policies that would meet these objectives are complicated by issues of equity among countries, differentiation of objectives according to national situations, timing of policies, and the practical matters of implementation. As the third Conference of the Parties approaches in December 1997, there has been a greater emphasis in public debate on the idea that whatever policies might be adopted to control emissions of greenhouse gases should rely upon market mechanisms. That is, producers of greenhouse gases should be able to incorporate a value of emitting them in their economic planning and decision making.

The likely details of an international agreement to result from Kyoto are not yet known. But it is clear that real commitments to reduce emissions of carbon dioxide and other greenhouse gases would effectively place a value on *not* producing them. This has been recognised since the early stages of the climate change debate. Emissions limits at the level of individual producers such as power plants or automobiles would implicitly place values on carbon dioxide emissions. Market-based policies would make the value explicit. In the case of carbon dioxide emissions from fossil fuel use, we may speak about a "carbon value" or the cost to energy users to emit carbon dioxide. (Equivalently, this may be thought of a value to not emitting carbon dioxide.) This value is today independent of the commercially determined fuel energy content.

Differences Among Energy Related Services

If indeed market-based instruments are chosen to meet the objectives of the climate treaty, in principle the carbon value will be the same regardless of end-use, sector, or the technical details of processes producing carbon dioxide. The effect upon individual energy end-uses is difficult to predict with certainty — in fact this is precisely why market-based solutions are preferred by many economists. Rather than relying on centralised, command and control measures in specific end-uses, market-based solutions can be expected to adjust energy use patterns across all end-uses in a way which minimises the overall cost of meeting the emissions goals. However, some general observations can be made on the likely effects of establishing a cost to emit carbon dioxide.

The following factors are among those that will affect the price of energy-related services as a function of carbon value:

- the fuel price increase due to carbon value;
- the fraction of service price that is fuel input;
- the ability to use fuels with lower carbon content and, hence, lower incremental cost increases due to carbon value (availability of substitute processes or equipment providing the same service);
- the rate at which substitute processes or equipment can be introduced.

Generally the denser the fuel, the higher the carbon content and the higher the production of carbon dioxide per unit of fuel energy. So a uniform carbon value would result in fractional price increases that vary by fuel, as shown in Table 1.

The cost of providing energy-related services using the existing mix of processes and equipment would rise according to the particular fuel used and the contribution of energy to the final price. For example, using the figure from Table 1 for gasoline, the cost of providing personal mobility would rise by very little. The presumed carbon value does not result in a large gasoline price increase and, furthermore, gasoline's fraction of automobile life-cycle expenses is typically less than one third, so the net effect on total costs is quite small ($2\% \times 30\% = 0.6\%$). In contrast, the effect of the same carbon value on the cost of providing an end-use using coal could be much higher. Table 2 provides several illustrative values of the ratio of fuel cost to total product cost.

Table 1. Effect of Carbon Value of US$ 20 per Tonne on Energy Prices

Fuel	Carbon Content (tonne C/toe)	1995 Avg. IEA Price (US$/toe)	Price Increment Due to Carbon Value (US$/toe)	Frac. Price Increase due to Carbon Value (%)
steam coal	1.13	§64	23	36
heavy fuel oil	0.88	141	18	12
natural gas (industry)	0.63	112	13	11
light fuel oil	0.79	260	16	6
gasoline	0.85	† 839	17	2
IEA electricity (equiv.)	‡ 1.30	1058	‡ 7	1

Source: IEA Energy Prices and Taxes, Secretariat calculations

Notes: ‡ Electricity consumption releases no carbon dioxide at the point of use. Average carbon content of electricity is calculated based upon average carbon dioxide emissions per unit of IEA electricity production. Similarly, price increment is based upon increased production cost passed through to final consumer, assuming no change in generating plant mix. Fuel is assumed to represent one quarter of total electricity cost on average throughout OECD.
§ Average steam coal price excludes Germany
†Gasoline price assumed to be 0.70 US$/li

Table 2. Fuel Cost as a Fraction of Total Product Cost

Equipment	Energy Source	Product	Fuel Cost / Total Life-Cycle Cost
automobile	gasoline	kilometres travelled	30%
refrigerator	electricity	refrigeration	40%
power plant	coal	electricity	50%
power plant	gas	electricity	70%
space heating system	natural gas	space heating	70%
electric motor	electricity	motion	90%

Note: Values are illustrative only.

If an energy-related service may be provided using a different energy source having a lower total cost, including the carbon emission cost, the effect of a carbon value would be to encourage fuel switching. This will tend to minimise cost increases due to a carbon value. In many instances, however, it is not possible to switch energy sources from among fossil fuels. This is particularly the case in the transport sector, where almost all energy consumption in road, marine, and aviation uses is without any close economic substitute to refined petroleum products. Similarly, in stationary energy end-uses outside of industry, it is often the case that few economic alternatives exist to allow interfuel competition. Examples are agricultural machinery and, in areas without access to a natural gas grid, space heating.

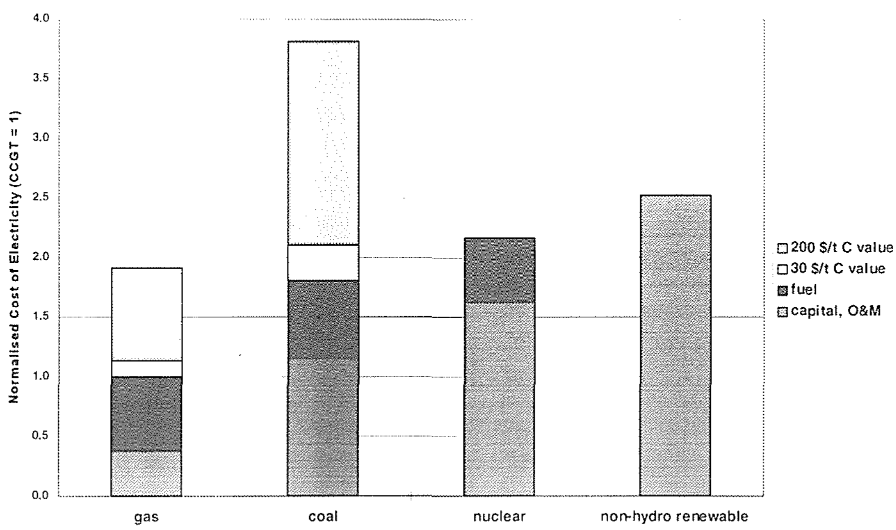
Industrial energy uses and electricity production are notably different from other energy-related services with regard to their potential for fuel switching. This is because energy typically accounts for a large fraction of final product price, and the quantities of energy used are sufficiently large to warrant dedicated infrastructure to deliver that energy. The ratios of carbon dioxide emissions from coal : petroleum products : natural gas use in OECD industry are 1 : 2.2 : 1.9 and in OECD power generation are 1 : 0.2 : 0.2. In the rest of the world, these ratios both for industry and power generation are about 1 : 0.3 : 0.2. These values indicate that there is large scope in both sectors, particularly power generation, for a shift towards lighter fuels if carbon values and fuel availability make it economically feasible. The close prices of heavy fuel oil and natural gas in many markets and existence of fuel-switching capability in both industrial and power sectors also suggest that development of a carbon value would lead to a shift towards natural gas.

Power Generation and Carbon-Free Energy Sources

Power generation would be strongly affected by limits on carbon emissions or an explicit carbon value. It accounts for roughly one third of all emissions of carbon dioxide, both in the OECD and worldwide. Fuel costs typically account for 50-80% of final cost of electricity, depending on the fuel and the capacity factor of the plant. It is also the single largest consumer of coal, whose final price is most sensitive to a carbon value. Power generation is unique in that it may use energy sources that produce no carbon dioxide and whose economics therefore would be unaffected by a carbon value arising from carbon dioxide limitations. These are of course nuclear and renewable energy, including hydroelectric. Because of the above factors, power generation potentially offers one of the largest sources of carbon dioxide reduction among the three main energy-related services.

Figure 3 shows the effect of a carbon value on the competitive position of fossil fuelled power generation and carbon-free power generation, including their capital costs. The figures are based upon the actual average prices of coal and natural gas for power generation, and assume a cost of electricity differential compared to coal of 20% for nuclear and 40% for non-hydro renewables. Although in practice fuel choices will be made by utilities based on their individual commercial situation and local pricing of equipment and fuels, it is clear from the figure that introduction of a carbon value could significantly alter the competitive position of first coal, then gas-fired power generation with respect to nuclear power and renewable power. Further, the carbon value at which the competitive position of the different fuels changes differs in each region and in each country.

Figure 3. Effect of Carbon Value on Power Generation Choice



Notes: Calculations are illustrative only and are based on IEA Secretariat estimates of input costs.
Cost of electricity assumptions: nuclear power 20% more expensive than coal plants; power from renewable energy 40% more expensive.

In countries with access to pipeline natural gas, gas-fired combined cycle gas turbines are typically the option providing the lowest cost of electricity for baseload power generation. They also have the advantage of releasing the least amount of carbon dioxide per kWh of any fossil-fuelled option, both because of their use of a low-carbon fuel and their high generation efficiency. These characteristics render them the least sensitive to a carbon value of the fossil-fuelled options. So, while the introduction of a carbon value would increase their production costs, this would improve their competitive position relative to other fossil-fuelled options and still leave them as formidable competitors to non-fossil generation options. The value of carbon would have to rise to 200-300 US$/tonne for nuclear power to be competitive with gas-fired power generation under the assumptions of this illustrative calculation.

In stark contrast, coal-fired power generation costs clearly would rise to the level of nuclear power at much lower levels of carbon value. Carbon values of 25-35 US$/tonne would bring nuclear power into competition with coal-fired power, while carbon values of 65-100 US$/tonne would bring non-hydro renewables into competition with coal. Regardless of the precise figures, coal-fired power generation, even with advanced technologies such as coal gasification combined cycle power plants, will become uneconomic compared to nuclear or renewable power well before gas-fired power production.

There are differences in the results of interfuel competition in the long term versus the short term. The above considerations, which take into account the cost of capital in power production, relate to long-term fuel/technology choices to minimise electricity production costs. In the short term, interfuel competition would be constrained by the existing stock of power production technologies and the rate at which it was economic to convert it or renew it. In those plants where switching to a less carbon-intensive fuel were technically possible, a carbon value could result in making the switch. Plants whose fuel sources could not be economically switched would tend to be operated at lower capacity factors. For example, coal-fired plants, which typically provide baseload power, could move towards load-following service given a sufficiently large carbon value. Nuclear plants, in the near term, could not play a significant role in adjusting to a carbon value since they generally are operated at their maximum capacity and could not provide much incremental output.

These realignments of comparative power generation costs would depend on the costs and availability of each of the energy sources in a local context. A basic precondition for interfuel competition and switching is the access to the less-carbon intensive energy supply. If, for example, natural gas is not available except by import of relatively expensive liquefied natural gas, a low carbon value might not have an impact on the results of gas-oil or gas-coal interfuel competition. Similarly, if natural gas is not available locally, a carbon value could cause a shift from coal- to oil-fired generation.

We may conclude from the discussion above that restrictions on carbon emissions in the power sector, either with implicit or market-based restrictions on carbon dioxide emissions, could place coal-fired power generation at a significant cost disadvantage, while favouring first gas-fired power, nuclear, and ultimately renewables. The results of interfuel competition in the near term depend on the availability and price of fuels in local markets. In markets where gas is currently competitive, it could remain so at carbon values which increase gas price by a factor of two or more. However, in the long term nuclear power and renewables place a limit on the level to which carbon value could rise, since their costs do not rise as a function of carbon value.

Market Determination of Carbon Value

As noted earlier, a value attached to the emissions of carbon dioxide (carbon value) would result from binding restrictions on emissions of carbon dioxide, or greenhouse gases in general. If emissions limits were allocated among sectors, costs of reducing emissions would be unevenly distributed. They would, however, still result in changes in the competitive position of different fuel/technology combinations to provide the same energy-related service. For example, coal would bear a heavier economic burden in all sectors. Carbon value would be implicit and would vary, perhaps greatly, by sector and by end-use.

On the other hand, if emissions limits were implemented in a market-based system, carbon value would be determined by the classic balance of market supply and demand forces. It would be uniform among all end-uses, drawing first on those end-uses having the least cost to reduce carbon emissions. As the requirement for emissions reductions grew, more expensive options could be called upon. The carbon value would rise accordingly. On the demand side, increases in the cost of energy-related services would also have an effect. As the cost of reducing emissions were included in prices to end users, consumption would decrease and contribute to restraining emissions growth.

Certain fuel/technology options would establish limits on carbon value until the full extent of their supply could be absorbed. They would depend on local market conditions, including fuel supply. For example, replacing heat-only heating systems by cogeneration heating systems might provide a supply of relatively inexpensive carbon dioxide reductions without necessarily switching the primary energy input. In a heavily urbanized area or cold country, this could conceivably supply emissions reductions equal to, say, several percent.

A more expensive source of emissions reductions might be industrial or power generation fuel switching in existing plants. A less expensive switch would be from oil to gas, since the difference in their prices is small in many markets. A more expensive switch would be from coal towards oil or gas. This is a much larger potential source since switching from coal to oil alone accounts for a 20% reduction in carbon dioxide emissions assuming the same efficiency of energy use. Switching to natural gas results in about a 40% reduction in carbon dioxide emissions. However, the carbon value at which switching would be economic from the energy user's point of view would correspond to the price difference between the two fuels without the carbon value. Coal prices would effectively double with a carbon value that made switching economic in existing plants.

In new industrial or power facilities, where the capital cost must be taken into account, the choice of natural gas is often the most economic even without a carbon value. As old facilities are replaced by new ones, natural gas may provide a larger share of energy supply. This would provide a relatively inexpensive source of carbon reduction. The relevant calculations for new power generation are illustrated in Figure 3. In summary, switching to lighter fossil fuels represents a relatively large source of potential reduction in carbon dioxide emissions. In a market-based approach to limiting carbon dioxide emissions, fuel switching could be expected to set a series of limits on carbon value until most fuel switching opportunities were exhausted.

In the long run, continued worldwide economic growth could be expected to lead to substantial increases in energy demand. As energy consumption increases in end-uses that do not have close economic substitutes for fossil fuel use — among which transportation figures most prominently — the need for deeper reductions in carbon dioxide emissions in other end-uses would grow. Carbon-free energy sources would ultimately provide a technically limitless source of carbon dioxide reductions. They would also set the economic limit to carbon value.

The largest sources of carbon-free energy are presently concentrated in electricity production: nuclear power and power generation from renewables. Any future carbon value would not itself alter the economic competition between them. Rather, technological development is the route by which nuclear or renewables will ultimately provide electricity at the lowest cost. On the basis of today's estimates of costs, nuclear power has an advantage compared to renewables in many markets. Nuclear power would, by providing the limit to carbon value, inevitably grow to meet the requirements of less carbon dioxide emissions in energy use.

This conclusion supposes that economics would be the deciding factor in the selection of nuclear power in future energy development scenarios. This is not by any means a supposition that will hold true. Nuclear power faces challenges beyond economic competitiveness which must be met before it can contribute to the world's future energy supply, with or without the effects of restrictions on carbon dioxide emissions.

A Potential Decline in Diversity of Energy Supply?

Since the oil shocks governments have been particularly concerned about energy security. Their general concern has been to reduce the potential economic consequences of a disruption in energy supply. The factors seen as having the potential to cause supply disruptions include technical failures, such as the rupture of a pipeline, failure to mobilise long-term investment at a rate commensurate with demand growth, or political disruptions of fuel supply. A fundamental measure to promote security is to diversify energy sources such that each provides a smaller proportion of supply and, hence, has a smaller effect if disrupted. Diversity may refer to the number of producers, the number of transport options, the number of supplying countries, or the number of different fuels.

It is the latter that might cause concern if energy use shifted towards lighter fossil fuels in order to reduce carbon dioxide emissions. If, for example, coal use diminished substantially and primary energy use shifted towards oil and natural gas, the diversity of fuel inputs would be decreased. The potential effects of a disruption in oil or gas supply could be potentially greater for regions heavily dependent on these fuels as their primary energy sources. In the long term, reliance on renewable energy could raise similar concerns. Nature's supply of energy is not always constant, as droughts may reduce hydroelectric output, winds may calm, or insects may devour an energy crop. Whether the result of restrictions on carbon emissions resulted in a shift to lighter fossil fuels or carbon-free sources of energy, there is the potential concern that energy diversity could be reduced.

The desire for energy security could give some advantage to nuclear power. In fact, the desire for energy security was an important force in the rapid development of nuclear power after the oil shocks of the 1970s. Considering the supply of uranium to be sufficiently diversified that its supply should not be subject to long-term interruption, countries have tended to regard nuclear as an "indigenous" energy supply which contributes to diversification of energy supply. In the past this meant diversification in relation to fossil fuels, and in the future this role could be accentuated by a concentration in lighter fuels. Could it also mean diversification in relation to renewables? If fossil fuel use diminishes in the future as carbon dioxide emissions are limited, or if fossil fuel use is concentrated in lighter fuels, could nuclear help to contribute to the diversity, and hence security, of energy supply? If these questions are answered positively by market forces or by government action, the economic position of nuclear power could be strengthened if carbon emissions are limited in the future.

Political Challenges for Nuclear

Although nuclear power now supplies about 7% of world total primary energy and one quarter of input energy to electricity (11% and one third in the OECD), it is not clear today that these shares can be expanded or even maintained in the future. Nuclear power has, in the last decade, seen a considerable change in its public perception, economics, and technical challenges. The period of nuclear power development from 1950 to 1980 might be characterised as one primarily of technical and commercial development of the power generation technology itself. The front end of the fuel cycle, that is enrichment and fabrication, were also developed in parallel.

The 1978 accident at the Three Mile Island Plant in the United States and the 1986 explosion of the Chernobyl plant in Ukraine substantially altered the pace and focus of nuclear power development. Safety in generation, always seen as of fundamental importance, took on even greater prominence. Costs of safety-related modifications to plant design and operation increased production costs, as did increased regulatory oversight in some countries. Competition from economical gas-fired combined cycles and improved coal-fired plants also appeared. In parallel, as the quantity of spent fuel increased from operating commercial reactors, the need for development of the back end of the nuclear fuel cycle became more apparent. The approaching retirement of some of the early plants also cast light on the need for more specific planning and substantial expenditures for plant decommissioning. Finally, baseload power growth has been relatively limited in the countries where nuclear power has heretofore developed the most. As a result of these trends, today only two OECD countries, Japan and France, have active nuclear power programs which expect new plants to be constructed after 2000.

The challenges facing nuclear power today are both economic and political. Arguably, the greater challenge is political. The most important issues are:

- public acceptance of nuclear power plants;
- development of the back end of the nuclear fuel cycle; and
- assurance that civil nuclear technologies and fuel will not be used for military purposes.

In fact the first two might both be described as one relating to public acceptance of nuclear power, because the chief impediment to either reprocessing or long-term storage of spent nuclear fuel is essentially political rather more than technical. Public acceptance of nuclear power also involves acceptance of related activities such as fuel and waste transportation, disposal of low level radioactive waste, emergency evacuation plans, operation of test reactors, and many other activities outside the confines of power generation stations. The violent demonstrations against reprocessed fuel shipments in Germany in March 1997 and the recurring public attention on reprocessed fuel shipments from France to Japan clearly illustrate this.

"Public acceptance" could alternately be described as "demonstration of nuclear safety." Public concerns ultimately stem from the fear that nuclear technology and materials could lead to release of unsafe levels of radioactivity into the environment. In this regard nuclear power plants have shown considerable technological progress since 1980 in improving safety through improved design and operational features. The historical absence of dangerous radiation releases from civilian nuclear power plants in OECD countries must be seen as a prerequisite for future maintenance or expansion of nuclear power in the OECD. New, simplified plant designs involving passive safety features could help both in obtaining public acceptance and improving the economics of nuclear power. Such designs have been under development since the 1980s and could potentially be used in any new plants.

Concerns about the fate of radioactive species in spent fuel has been a serious impediment to development of adequate plans and facilities for isolating civilian nuclear wastes from the environment. Spent fuel reprocessing in particular has been impeded by concerns about the fate of plutonium and making sure that it is not used for military purposes. In a number of countries the issue of spent fuel storage has reached a stage of near paralysis in public debate, as for example in the United States. There, the government administration has been unable to develop definitive plans for a permanent high-level waste repository, even as the judicial branch has been brought into play to enforce the now 15 year old law requiring such plans. In Germany and the United Kingdom, the sites identified as the most likely ones for waste storage face strong public opposition. Plans for reprocessing of wastes have been similarly blocked by safety concerns and, the last of the three main political challenges identified above, the fear of nuclear weapons development.

Non-proliferation is a key political challenge for nuclear. At the 1996 annual meeting of the American Nuclear Society, one commentator went so far as to state that the "sustainability of nuclear power is in the management of plutonium." This could be true from both a technical and political standpoint. The plutonium produced in light water reactor fuel is not directly usable from spent fuel elements, but reprocessing to isolate and reuse plutonium in mixed oxide fuel poses a problem with potential diversion for military purposes. The 1970 Non-Proliferation Treaty was indefinitely extended and strengthened in 1995, and the number of parties to it has grown to 178. It is the main international instrument for supporting the objective of non-proliferation. Still, it is not universal, and several countries not party to it have active civilian nuclear programs. Further, the safeguards it provides must be adequately implemented for it to be effective. Strengthening the functioning of the Non-Proliferation Treaty must be an important part of the development of civilian nuclear power. Nine countries[4] initiated a parallel effort in 1994 to establish an international framework to increase the transparency in the management of plutonium. The first agreement of the group was to make public their inventories of civil plutonium. A wider effort along these lines would also help address this challenge to the future of nuclear power.

Although the discussion on carbon value indicates the potential economic advantage that might accrue to nuclear power if carbon emissions are firmly restricted, particularly in the long term, the movement towards competitive markets in power generation poses additional challenges for both nuclear power and renewable power in the near term. Nuclear power has been developed throughout the world in regulatory regimes which have allowed utilities to fully recover costs of nuclear power programs from electricity consumers. In addition, civilian nuclear technology development has been aided by government programs in research and development, fuel enrichment, reprocessing, and storage. That certain nuclear power plants may not have been the most economic generation choices, seems, in hindsight, to be borne out by discussions of stranded costs in electricity supply systems that are contemplating the introduction of competition in generation. Renewable energy today is heavily subsidised in many countries around the world. It faces the same issue of competitivity that nuclear power does in relation to fossil fuels. In the future it might also be drawn into a debate on stranded costs if renewable energy subsidies were to be removed. So while both nuclear and renewable power could become more competitive with carbon dioxide restrictions, long before fossil fuels decrease significantly in use they must demonstrate economic viability, without government subsidies, in more competitive power markets.

Conclusions

Past patterns of energy use in OECD countries show the strong links between economic growth and energy use. Policies to address climate change concerns cannot ignore these links. Any measures taken to curb carbon dioxide emissions from energy use must also recognise that each energy-related service sector and individual end-uses will have different options available to reduce carbon dioxide emissions. Each sector and end-use will have different costs associated with emission reductions.

The IEA believes that open, undistorted markets are the best means to ensure the efficient use of energy both now and in the future. In the context of climate change policies this remains true. Thus, if firm restraint is agreed upon by parties to the climate treaty, the advantages of market-based policies to restrain carbon dioxide emissions are evident. Regardless of the form of policies ultimately devised, restrictions on carbon dioxide emissions will lead to the development of a carbon value, or a value to reducing emissions.

A carbon value will change the results of interfuel competition, tending to favour lighter fossil fuels and more efficient power production. In some end-use sectors, particularly transport, there are few alternatives to liquid petroleum fuels, and a carbon value would have minimal effect on the immediate prospects for economical fuel or technology switching. In other sectors, particularly electric power, production processes can take advantage of fuel switching to lower carbon dioxide emissions while minimising final cost increases. Natural gas is favoured in the near term, but higher carbon values could ultimately make nuclear power and renewables less expensive options compared to fossil fuel.

The competitive position of nuclear power might be strengthened if market forces or government policy were to give energy security a renewed importance. A shift towards lighter fossil fuels, particularly a decrease in coal's share of primary energy, would tend to reduce the diversity of fuel supply and raise concerns about the

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[4] Belgium, China, Germany, France, Japan, Russia, Switzerland, the UK and the US.

potential for its disruption. In the long term, a concentration on renewable energy, which has a natural component of variability, could tend to give a value to the improvement in diversity attainable using nuclear power.

A carbon value determined by market forces would be limited by sources of carbon dioxide reduction obtainable from various fuel/technology options. In the near term such limits would relate to fuel switching among fossil fuels. In the long-term the carbon-free energy sources of nuclear power and renewables provide an upper limit for carbon value.

Nuclear power faces political obstacles that must be overcome if it is to provide such a limit on carbon value. Public concerns about safety, waste storage or disposal, and non-proliferation are critical areas that must be addressed. Neither the nuclear industry nor governments should look to the climate change debate to ensure the future of nuclear power. The desire to reduce carbon dioxide emissions will not lead to greater use of nuclear power, even if it may be an economic solution, if some of the non-economic impediments to its use are not removed in the coming years.

Should these obstacles be overcome, nuclear power could make an important, positive contribution to reducing carbon dioxide production from energy use. Should the Kyoto conference result in firm international commitments to reduce emissions of greenhouse gases, a cooperative framework for sharing the expense of these commitments will inevitably be a part of it. In developing countries, where electricity growth is strongest, nuclear power could grow within this framework and help in the search for a model of sustainable development.

パネル「代替エネルギーの役割と未来」に対する主張要旨

明治大学理工学部教授　藤井　石根

「外界や周囲に何らかの作用や影響を及ぼし得るもの」をエネルギーと呼んでいる。従って、電力やガソリンなどを使うと、環境に必ずや影響を与える。これまで我々は、石炭や石油など、核エネルギーも含めて、ハードエネルギーと呼ばれるエネルギー源を、使い放題に使い、かつ、利用上の便利さから、主としてこれを利用してきた。当然我々の現在の生活環境は、この利用に沿う形で社会システムもライフスタイルも出来上がってしまっている。

他方、ソフトエネルギーと呼ばれている太陽エネルギーや風力など、自然のエネルギーは、これを利用することに伴う環境への影響は、ハードエネルギーの場合に較べて、総じて非常に小さいが、利用面や量的な制約があり、これが嫌われて、これまでそれ程利用されていない。しかも、先進国と目されてきた国々では概ねこれまでのハードエネルギー源を主体とした社会システムやライフスタイルを堅持、でき得れば今後もこの状況を続けていきたいと願っている。加えて、経済成長が著しい東南アジア諸国も、先進国が歩んだ同じ道を歩もうと奔走している。

こうした世界の動きを背景に、

① 石油などエネルギー資源の急激な枯渇への懸念
② ハードエネルギー源の多消費に伴う地球レベルの環境悪化
③ どうにも解決の糸口すら見出せない多量に蓄積され続けている負の遺産

等の問題が、我々の頭上に重く、かつ大きくのしかかろうとしている。

それにも拘わらず、世界はこの問題の解決に向けての有効な手だてを殆ど打ち出しておらず、総じて己の目前の利益の確保に汲々としている。個人のレベルにしても、こうした傾向が概して色濃く反映されている。

しかしこうした行為を続けることは早晩、立ち行かなくなることは、明白であり、多くの人達もこの事を肌で感じ始めている。それでも尚、人は、往々にしてかかる状況下に己が置かれることはないものと信じ、安心を装っている。しかし、こうした問題が現実性を帯、それが次第に増してきた時、その時点での解決の道はもはや皆無であることを我々は知らねばならない。

そこで筆者は、この場を機に、次のことを強く主張しておきたい。

1）人も含め、全ての動植物がこの世で生存しうる環境を確保する為、ソフトエネルギー源を主体とした、社会システム、ならびにライフスタイルを１日も早く構築すること。
2）エネルギー源の安定供給、持続可能性を確保するために、より多くのソフトエネルギーの活用を図ること。
3）必要性に応じたエネルギーの選択的な利用を図り、かつ省エネルギーの徹底を図ること。
4）負の遺産の蓄積、増大を極力抑えること。
5）環境が損なわれた場合に被る損害の程を考慮に入れた経済判断を軌道に乗せること。また「資源生産性の原則」並びに「再生の原則」を我々の経済観念の中に導入しなければならない。

他方、上記事項を実現する具体的な方策としては、

Ⅰ）炭酸ガス税のような、外部コストの導入を検討する。
Ⅱ）ソフトエネルギーの活用の技術開発を一層進める。
Ⅲ）大量生産、大量消費といったこれまでのやり方を改め、廃棄物処理費用の負担の明確化を徹底させる。
Ⅳ）廃棄物の再資源化、再利用を一層進める。

等が当面考えられよう。

Opinions summarized for the panel

Dr. Iwane Fujii

Energy is defined as an ability which can give any effects or influences to the surroundings or the outside.So,the environment is always affected more or less by our consumption of electric power,gasoline and so on.

Until now freely abundant usage and handling easiness for user enable us to use mainly hard energy resources represented by coal,petroleum and the like,including nuclear energy.Accordingly,our present life style and the social system are all compromised with mass consumption of hard energy resources.

On the other hand,in spite of less environmental damage by usage of soft energy resources such as wind power and solar energy,quantitative and handling restriction in use at a time have prevented our positive utilization of soft energy hitherto.Further,there remains still strong expectation for keeping the above-mentioned situation in the developed countries,whereon the peoples especially in the southeast countries having recent marked economical development also expect much to trace same process as the developed countries did.

Such a global situation is going to bring on the following problems heavily and world-widely:

1) Fear for rapid depletion of hard energy resources especially as oil:
2) Various aggravations for the global environment mostly brought by mass consumption of hard energy resources:
3) Much troublesome substances being accumulated day by day:

The world,however,have still no effective counterplans to avoid these difficulties and are eager for getting immediate profiles in general,which are also reflected even to the invidual,Most persons have more or less interest in these problems,but most of them think that they are the last man to encounter the prospective difficulties.

Anyway,in view of the fact that there is no way to cure the coming disease for the environment the author would like to insist on the next items here:

Ⅰ) Urgent realization of life-style and social system principally based on soft energy resources to keep sound environment where all creatures can be alive:

Ⅱ) Insurance of sustainability and stabilized energy supply through more soft energy utilization:

Ⅲ) Adequate energy saving and selective use of energy:

Ⅳ) Expulsion of accumulation of troublesome substances:

Ⅴ) Introduction of economical efficiency involving the estimated loss for environmental aggravation:

Concrete measures to realize the above items are considered as follows:

a) Introduction the external cost such as CO_2 tax and the like:

b) Further technical development for soft energy utilization:

c) Establishment of clear-cut lines for disposal cost payer of waste materials:

d) Conversion of mass production and mass consumption to effective and saving use of every resources:

e) Further advancement of reuse and recycling of waste materials:

代替エネルギーの役割と未来

財団法人　日本エネルギー経済研究所
常務理事　　　藤　目　　和　哉

１．第一次石油危機以降の石油代替のトレンド

日本のエネルギー政策は、第一次石油危機以来、省エネルギーと石油代替の促進を２本の柱としてきた。省エネルギーは、日本においては、1980年代半ばの原油価格暴落まで急速に進んだが、1980年代半ば以降原油価格低下に円高効果が加わって経済的インセンティブがほとんどなくなり停滞している。石油代替については、1973～85年度に一次エネルギー供給に占めるシェアが77.4%から56.3%へ21.1%に縮小し、反面原子力、天然ガスのシェアが同時期に1.5%から18.3%に16.8%拡大した。石油のシェアは1995年度に55.8%と10年間で0.5%しか下がっていない。原子力、天然ガスは1995年度に22.8%と10年間で4.5%シェアを増大させたが、そのテンポは鈍っている。背景には石油に対する経済性の優位度の低下もあるが、原子力の立地難による計画の遅れはエネルギー需給構造の改善に大きなマイナスのインパクトを与えたことは見逃せない。

２．今後の20年間の石油代替の見通し

(1)一次エネルギー供給

一次エネルギー供給の増加が1995～2015年度まで年率1.2%（ＧＤＰ年率2.2%を前提）とする。石油供給の伸びは年率0.5%で伸び、一次エネルギー供給中の石油のシェアは1995年度の55.8%から2015年には49.0%と6.8%減り、代わりに原子力、天然ガスのシェアは、同時期に12.0%、10.8%（計22.8%）、から14.1%、13.7%（計27.8%）へと5.0%、石炭が16.5%から18.9%へと3.3%増える。

化石燃料（石油、石炭、天然ガス）は、1995年度の石油換算４億8800万ｋｌ、一次エネルギー供給中シェア83.2%から2015年度は、石油換算６億1300万ｋｌへと年率1.1%で伸びて一次エネルギー供給中シェアは81.6%と20年間でわずか1.6%しか減らない。絶対量では、化石燃料は石油換算で25.6%も増え、その結果炭酸ガス（CO_2）排出量は、25.8%増加する。

このような現象は、原子力開発計画が立地難等で遅れるため（2010年において原子力発電計画70ＧＷに対し、58ＧＷに止まる見込み）、その遅れ分を石炭、天然ガス、石油火力でカバーせざるを得ず、その結果CO_2排出量が増える（1990年レベルに対し2010年に30%増、2015年に35%増）。2010年の海外依存度も政府目標の75.4%が81.7%に止まる見込みである。

原子力の持つCO_2を排出しない利点、準国産エネルギーであることの利点を計画通り生

かすことができなくなることは、日本のエネルギー安全保障、地球温暖化防止政策にとって重大事である。

(2)電力供給

1995～2015年度の発電電力量は、年平均2.2%で伸びる見込みである。原子力は電気事業用総発電量中、1995年度で33.4%であったが、原子力による発電量も1995～2015年度で年率2.2%の伸びに止まり、2015年度における原子力のシェアは33.3%とほとんど変わらない。これは、政府の原子力目標シェア42%（2010年度）を大幅に下回る。

表　一次エネルギー供給見通し（基準ケース）

エネルギー	単位	1994年度 実績	2000	00/94	2005	05/00	2010	10/05	2015	15/10
水力	億kWh	685 (2.9)	889 (3.5)	4.5%	955 (3.4)	1.4%	955 (3.2)	0.0%	955 (3.1)	0.0%
地熱	万kl	64 (0.1)	116 (0.2)	10.6%	137 (0.2)	3.3%	137 (0.2)	0.1%	138 (0.2)	0.1%
石炭	100万t	127 (16.0)	150 (17.7)	3.0%	171 (18.4)	2.5%	187 (18.9)	1.7%	195 (18.9)	0.9%
一般炭	100万t	62 (7.1)	82 (8.7)	4.8%	104 (10.2)	4.9%	123 (11.4)	3.4%	135 (11.9)	1.9%
原料炭	100万t	65 (9.3)	68 (9.0)	0.7%	67 (8.2)	-0.2%	66 (7.5)	-0.5%	64 (7.0)	-0.7%
天然ガス	100万t	45 (10.8)	57 (12.7)	4.1%	65 (13.3)	2.6%	69 (13.3)	1.2%	74 (13.7)	1.5%
原子力	万kW	4,037 (11.3)	4,508 (12.1)	1.9%	5,005 (12.3)	2.1%	5,800 (13.4)	3.0%	6,400 (14.1)	2.0%
新エネルギー等	万kl	640 (1.1)	712 (1.1)	1.8%	712 (1.1)	0.0%	770 (1.1)	1.6%	828 (1.1)	1.5%
石油	億kl	3.32 (57.4)	3.31 (52.9)	-0.1%	3.48 (51.4)	1.0%	3.60 (50.0)	0.7%	3.69 (49.0)	0.5%
合計	億kl	5.77 (100.0)	6.24 (100.0)	1.3%	6.77 (100.0)	1.6%	7.19 (100.0)	1.2%	7.51 (100.0)	0.9%
経済成長率(GDP)		94/85 4.3	00/94 2.3		05/00 2.7		10/05 2.1		15/10 1.7	
エネルギー/GDP弾性値			0.569		0.606		0.584		0.518	
CO_2排出量(100万t-C)		336.8	357.6		388.1		409.2		423.9	
(1990=100)		107.2	113.8		123.6		130.3		135.0	
CO_2排出量/国内エネルギー供給 (100万t-C/10^{13}kcal)		0.6308	0.6195		0.6200		0.6150		0.6371	
一人当りCO_2排出量(t-C/人) (1990=2.54)		2.7	2.8		3.0		3.2		3.3	

（注）（）内は構成比：%

Roles and Future of Alternative Energies in Japan

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1. Post-First Oil Crisis Trends of Oil Substitution

Since the first oil crisis, Japan's energy policy has underlined the promotion of energy conservation and oil substitution as its two pillars. Energy conservation in Japan has been rapidly in progress until the collapse of crude oil prices in the mid 1980s, but on the wane afterward because falling crude oil prices, combined with the strong yen, have nearly dispelled economic incentives. In regard to oil substitution, oil share in primary energy supply shrank 21.1% from 77.4% to 56.3% in FY1973-85, while the shares of nuclear and natural gas expanded 16.8% from 1.5% to 18.3% over the same period. In FY1995, oil share stood at 55.8%, down a mere 0.5% over the past decade. Nuclear and natural gas increased their shares to 22.8% in FY1995, up 4.5% over the decade, but the tempo has been slowing down. In the background, aside from their shrinking economic superiority to oil, it can not be overlooked that delays in nuclear development plans, largely due to siting difficulties, have had a considerable negative impact on the improvement of energy supply/demand mix.

2. Outlook for Oil Substitution for the Next 20 Years

(1) Primary Energy Supply

On the assumption that primary energy supply grows 1.2%/year (if GDP to go up 2.2%/year), oil supply would grow 0.5%/year and oil share in primary energy supply would go down 6.8% from 55.8% in FY1995 to 49.0% in 2015. Instead, nuclear and natural gas would increase their shares from 12.0% and 10.8% (22.8% when combined) to 14.1% and 13.7% (27.8% when combined), or a 5.0% increase, over the same period. Coal share would rise 3.3% from 16.5% to 18.9% during the same period.

Fossil fuels (oil, coal, natural gas), which amounted to 488 million kl oil equivalent and occupied 83.2% of total energy supply in FY1995, would increase 1.1%/year to 613 million kl in 2015. It means their share should drop a scant 1.6% over the next two decades. In absolute terms, fossil fuels would swell a hefty 25.6% in terms of oil equivalent. As a result, carbon dioxide (CO_2) emissions should rise 25.8%.

These phenomena stem from dragged nuclear development plans by siting difficulties (only 58 GW out of planned 70 GW achievable as of 2010). The gap should be covered by burning coal, natural gas and oil at power plants without any choice, which, in turn, inevitably boosts CO2 emissions (up 30% in 2010, and up 35% in 2015 over 1990 levels). As of 2010, Japan's overseas energy dependence would be 81.7%, compared with the government target set at 75.4%.

If Japan won't be able to use such nuclear advantages as a CO2-free quasi-indigenous energy as planned, it would be a matter of great concern which can jeopardize Japan's energy security and the government policy to arrest global warming.

(2) Electricity Supply

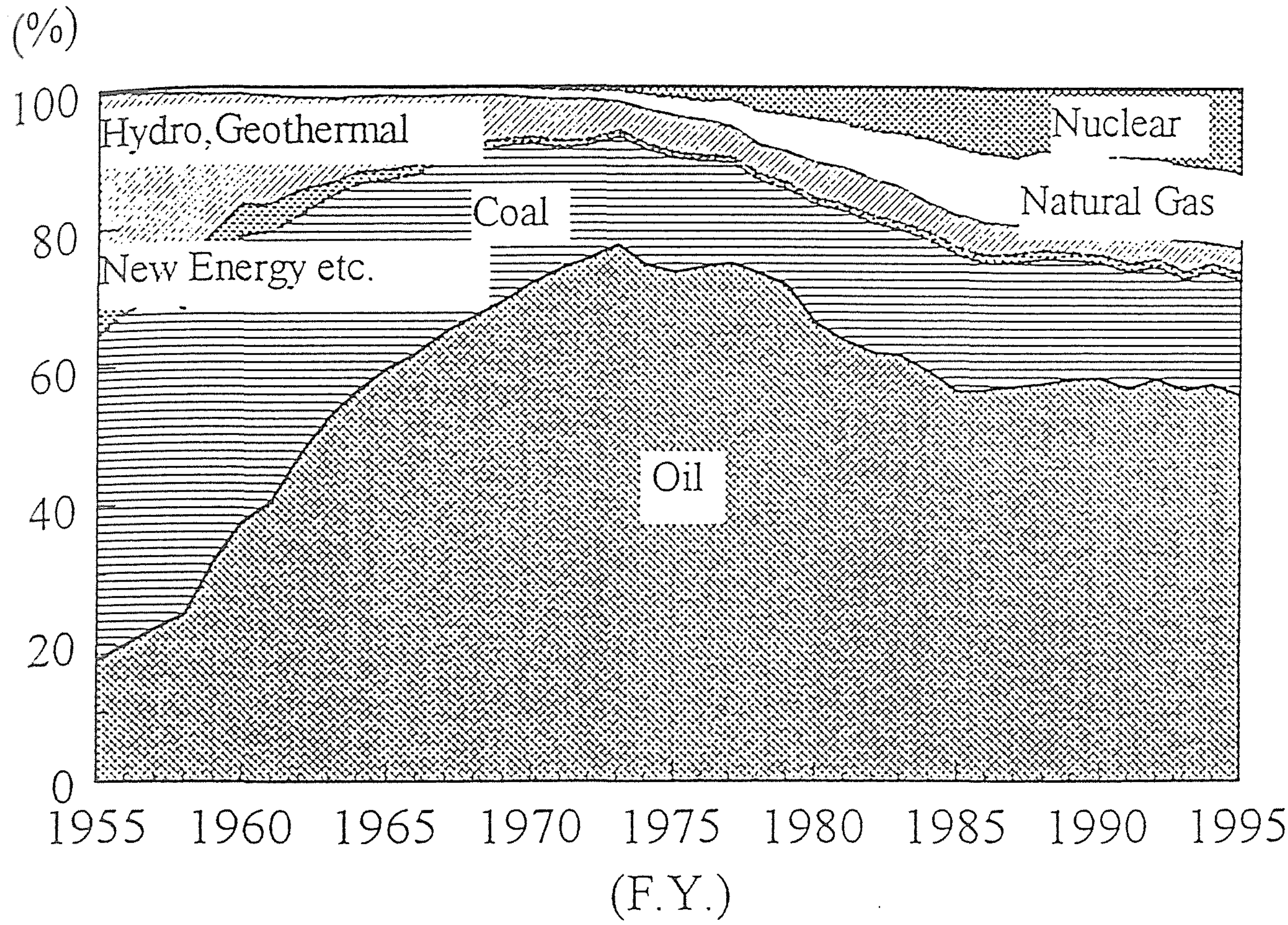
In 1995-2015, generated output is expected to grow an average 2.2%/year. Nuclear was responsible for 33.4% of total generated output in FY1995. However, with nuclear generated output likely to grow a low 2.2%/year between FY1995 and FY2015, nuclear share would remain almost unchanged at 33.3% even as of FY2015. This represents much below 42%, the government target (for FY2010) stated in its White Paper on Nuclear.

Table Primary Energy Supply Forecast (Base Case)

Energy	Unit	FY1994 actual	2000	00/94	2005	05/00	2010	10/05	2015	15/10
Hydro	TWH	68.5 (2.9)	88.9 (3.5)	4.5%	95.5 (3.4)	1.4%	95.5 (3.2)	0.0%	95.5 (3.1)	0.0%
Geothermal	10,000kl	64 (0.1)	116 (0.2)	10.6%	137 (0.2)	3.3%	137 (0.2)	0.1%	138 (0.2)	0.1%
Coal	mil. t	127 (16.0)	150 (17.7)	3.0%	171 (18.4)	2.5%	187 (18.9)	1.7%	195 (18.9)	0.9%
Steaming coal	mil. t	62 (7.1)	82 (8.7)	4.8%	104 (10.2)	4.9%	123 (11.4)	3.4%	135 (11.9)	1.9%
Coking coal	mil. t	65 (9.3)	68 (9.0)	0.7%	67 (8.2)	-0.2%	66 (7.5)	-0.5%	64 (7.0)	-0.7%
Natural gas	mil. t	44 (10.8)	56 (12.7)	4.1%	64 (13.3)	2.6%	68 (13.3)	1.2%	73 (13.7)	1.5%
Nuclear	10 MW	4,037 (11.3)	4,508 (12.1)	1.9%	5,005 (12.3)	2.1%	5,800 (13.4)	3.0%	6,400 (14.1)	2.0%
New energies/others	10,000kl	640 (1.1)	712 (1.1)	1.8%	712 (1.1)	0.0%	770 (1.1)	1.6%	828 (1.1)	1.5%
Oil	100 mil. kl	3.32 (57.4)	3.31 (52.9)	-0.1%	3.48 (51.4)	1.0%	3.60 (50.0)	0.7%	3.69 (49.0)	0.5%
Total	100 mil. kl	5.77 (100.0)	6.24 (100.0)	1.3%	6.77 (100.0)	1.6%	7.19 (100.0)	1.2%	7.51 (100.0)	0.9%
Economic growth (GDP)		94/85 4.3	00/94	2.3	05/00	2.7	10/05	2.1	15/10	1.7
Energy/GDP elasticity			0.569		0.606		0.584		0.518	
CO_2 emissions (mil. t-C) (1990 = 100)		336.8 107.2	357.6 113.8		388.1 123.6		409.2 130.3		423.9 135.0	
CO_2 emissions/domestic energy supply (mil. t-C/10^{13}kcal)		0.6308	0.6195		0.6200		0.6150		0.6371	
Per capita CO_2 emissions (t-C/capita) (1990 = 2.54)		2.7	2.8		3.0		3.2		3.3	

(Note) In parenthesis are shares (%).

Trends in Primary Energy Supply



(10^13 kcal)

F.Y.		1960	1970	1973	1975	1979	1980	1985	1990	1995
Primary Energy Supply		101	320	385	366	411	397	405	486	544
Shares (%)	Oil	37.6	71.9	77.4	73.4	71.5	66.1	56.3	58.3	55.8
	Coal	41.2	19.9	15.5	16.4	13.8	17.0	19.4	16.6	16.5
	Natural Gas	0.9	1.2	1.5	2.5	5.2	6.1	9.4	10.1	10.8
	Nuclear	-	0.3	0.6	1.5	3.9	4.7	8.9	9.4	12.0
	Hydro	15.7	5.6	4.1	5.3	4.6	5.2	4.7	4.2	3.5
	Geothermal	-	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.2
	New Energy etc.	4.6	1.0	0.9	0.9	1.0	1.0	1.2	1.3	1.1

Source:Energy Balance Tables in Japan (EDMC/MITI)

タイにとっての代替エネルギー源としての再生可能エネルギー

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１９７３年の石油危機以降、タイの歴代政府はエネルギーに関わるさまざまな機関と省庁に対し、タイのエネルギーミックスに関する計画に再生可能エネルギーを導入する可能性を真剣に検討するよう依頼してきた。太陽光、風力、水力、地熱、およびバイオマスがすべて調査、実験され、その経済的成立性が調査された。

タイの場合、総発電量は１９９６年９月末までに１，６１２万９，０００ｋＷを記録し、発電用に各種燃料が使用されている。その内訳は、天然ガス２６．８％、燃料油２５．６％、褐炭２０．９％、水力８．３％、ディーゼル４．６％、それ以外に再生可能エネルギーとその他燃料となっている。

１９９６年の最初の９カ月間に、タイの電力需要は前年同月比で７．０％増加した。政府のコジェネレーションを含む再生可能エネルギー優遇政策は民間のＳＰＰ（小規模発電業者）の間で広く知られているが、本稿では現在利用されている再生可能燃料、およびその発展の可能性の概要を示す。

たきぎ、木炭、もみがら、およびバガスなどの農林業廃物のエネルギーは、農村の家庭と小規模工場で広く使用されてきた。１９９４年には、たきぎによる調理で約７，１５０万立方メートルが消費された。砂糖工場で見られるバガスを利用するコジェネレーションは、およそ１，５００万のバガスを使用したのに対し、もみがらおよびその他の農業廃物は１９９４年に推定４，６６０万トンが燃料として使用された。全国の９つの州で都市ごみを燃やして発電を行う計画が検討されているところである。さらに、カッサバ（タピオカ）などのエネルギー作物が将来の小規模発電に有望な燃料として研究されてきた。カッサバは現在のところ、たとえば褐炭よりも価格が高いため、発電用燃料としては経済的に成立しないことが判明している。タイ発電庁（ＥＧＡＴ）は長年、発電用風力タービンを実験している。プケト島にあるサイトは平均風速が５ｍ／ｓであり、合計容量が４２．３３ｋＷｅの風力タービン発電機が４対設置されている。

水力発電は再生可能エネルギーとしては、ずば抜けて大きく、総発電設備容量は２８６万１，０７０ｋＷである。本稿では、太陽光（ＰＶ）のような他の再生可能エネルギーの利用の可能性についても検討しているが、今後数年間に、ＰＶは農村電化計画の対象とならない遠隔地で広がり始めるであろうと思われる。

Renewables as alternative energy sources for Thailand.

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Following the oil crisis in 1973, the governments of Thailand have commissioned various institutions and agencies relating to energy issues to seriously look into the possibilities of introducing renewable energy into the country's plan for energy mix. Solar, Wind, Hydro, Geothermal and Biomass have all been investigated and experimented and their economic viabilities studied

For Thailand, the total power generation was recorded at 16, 129 MW by the end of September 1996, with various types of fuels used in the electricity generation namely Natural Gas 26.8%, Fuel Oil 25.6%, Lignite 20.9%, Hydro 8.3%, Diesel 4.6% and others including renewables as remaining balance.

The first 9 months of 1996 saw Thailand's demand for electricity increased by 7.0% over the same period in 1995. The government's favorable policies towards renewables including cogeneration have been aware among the private SPP (small power producers) and this paper presents an overview of renewable fuels currently in use and their potential development.

Energy from agricultural and forestry wastes namely fire woods, charcoal, rice husks and bagasse have been used widely in rural households and small-scale industries. Cooking by fire-woods consumed some 71.5 million cubic metre in 1994. Bagasse-based cogeneration, as practices in sugar mills, used approximately 15 million of bagasse, whereas, rice husks and other agricultural wastes were used as fuels at an estimate of 46.6 million tons, in 1994.

The plan to burn municipal wastes to generate electricity in 9 provinces throughout the country is being considered. In addition, and energy crop such as cassava (tapioca) has been investigated as possible fuel for future small scale power generation. It has been found that cassava is currently uneconomically viable as fuel for power generation owing to its higher price than, say, lignite.

The Electricity Generating Authority (EGAT) has long been experimenting with wind turbines for power generation. The site at Phuket island has an average wind velocity of 5 M/S and has been installed with 4 units of wind turbine-generating sets with total combined capacity of 42.33 kwe.

Hydro power generation is by far the largest among renewables, with total installed capacity of 2,861.07 MW. The paper also looks at the availability of other renewables like solar (photovoltaic), where during the next several years, PV will be more acceptable in those remote communities which can not be served by rural electrification programme.

RENEWABLES AS ALTERNATIVE ENERGY SOURCES FOR THAILAND.

by

Kulthorn Silapabanleng

1. CURRENT ENERGY SITUATION IN THAILAND

Thailand has long been regarded as a net energy importing country. In 1994, as reported by the Department of Energy Development and Promotion (DEDP), out of the total primary energy supply of the country of 65,825 million tons of oil equivalent 43% is imported. Among the energy imported in 1994, crude oil is the largest proportion of all accounted for 66%, followed by petroleum products 30% and coal 3%.

The contribution of domestic energy production to the country's energy supply is due almost equally between modern and renewable energy. The modern, domestic energy production in 1994 is accounted for 48%, consisting of 25% natural gas, 14% lignite, 7% crude oil and condensate and 2% hydropower. The renewable energy takes a greater part of domestic energy production accounted for 52%, distributed into 43% fuel wood, 7% bagasse and 2% paddy husk.

The final energy consumption by economic sectors is interesting that the percentage use in the transportation sector is almost unchanged and remains at 37%, the largest of all, since 1990 till 1994. The manufacturing sector consumes 32% of final energy, the residential and commercial 27% and the rest 4% is consumed in the agriculture, construction and mining sectors.

Due to rapid economic growth during the past decade, Thailand's electric energy consumption has increased at considerable high rates. The highest increase of 16.5% was in 1990 when the economic growth was double digits at 10.3%. The electric energy consumption in 1994 was 62,510 Giga Watt-hours (GWh), an increase of 11% from previous year. The peak

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generation was almost 11,000 Mega Watts (MW). The industrial sector consumes the largest proportion of all accounted for 46% in 1994, followed by commercial sector 32% and residential sector 20%. Main sources of electric energy production in 1994 are from domestic natural gas accounted for 44%, fuel oil 28%, lignite 20%, hydropower 6% and diesel oil 2%. A very small fraction of renewable energy, geothermal and solar energy, of 1.1 GWh is contributed to the electric generation by the Electric Generating Authority of Thailand(EGAT). A numner of privately own and industrial power generating plants are producing power from renewable energy sources, such as, bagasse, other agricultural residues and industrial wastes.

2. CURRENT NATIONAL ENERGY POLICY

The national energy policy was drafted by the National Economic and Social Development Board for the Seventh Five-Year National Plan period between 1992-1996 and was approved by the Cabinet to be used as guidelines for implementing the energy development programs in the same period. The five-point energy policies are written as follows:

1. To provide energy to meet the demand of the country, with security and at reasonable prices.
2. To enforce the efficient use of energy and energy conservation measures.
3. To increase the role of private sector and to reform the energy administration systems in the government sector to become more integrated.
4. To conserve enviroment and protect the communities from the impact of energy production and utilization.
5. To distribute well-beings to the rural area and new economic zones as a result of energy development.

The National Energy Policy Office (NEPO), acting as the secretariat to the National Energy Policy Board (NEPB), chaired by the Prime Minister, is the sole national government agency responsible for the control and implementing the country's energy policies. In executing the energy policies, there are a number of government agencies and state enterprises looking after. Those agencies are Department of Energy Development and Promotion(DEDP), Department of Mineral Resources (DMR), Petroleum Authority of Thailand (PTT), Department of Industrial Works.

3. OIL AND POWER SUPPLIES

3.1 Oil Supply

Normally, transportation of petroleum products from refineries to provincial areas in Thailand is by fleets of trucks which most of them have to travel through Bangkok and the surrounding areas causing a lot of problems in the cities, such as traffic congestion, inefficient use of energy and, consequently, air pollution and greenhouse gases production, contributing to the problems of golbal warming and climate changes. The government has set up a policy and measures to cope with these problems by giving incentives to private companies to run pipelines from oil refineries to provincial industrial areas, at the same time, discouraging the traditional transportation by trucks by limiting the truck times traveling through Bangkok only at night time between 10 p.m. 5 am. This policy has multiple advantages for the country in reducing traffic congestion in the cities, reducing air and noise pollution and water pollution due to oil leakage into the river. Moreover, it helps conserve energy in the transportation sector. As the country is growing economically, oil transportation and distribution system should be changed from micro transport to mass transportation.

There are a number of policies and measures aiming at securing the country's oil supply but having no motives from environmental concerns which will not be discussed in this article.

3.2 Power Supply

In order to increase country's capabilities in electric power supply, private sector is be allowed to take part in the power generation so that competitiveness for high efficiency of power production would exist. For a long time, EGAT has been the sole government enterprise supplying electric power to the whole country. The marginal cost and cost plus basis has been used to set up the tariff rates. There have been none competitions so far. In December 1994, the government has approved a private sector involvement policy allowing private companies to produce electricity for sales in the so-called Independent Power Producers or IPP Policy. As a first step towards privatization, EGAT has announced for proposals from IPPs to generate and sell 3,800 Megawatts to the grid. This policy has turned the power generation monopoly which has been seen and known as public utilities into power business allowing international competition where new technologies could be widely introduced to yield high efficiency power production while having less negative impact to the environment. This can be viewed as having stemmed from both economic and environmertal concerns.

Small Hydropower Development. Hydropower has played an important role to power production for Thailand since the beginning of bulk power supply some 30 years ago. Today, large hydropower contributes only 8% of electricity supply. However, there are a considerable number of hydropower sources scattering mainly in the North and the South. The principal plan is to develop some 50 megawatts small hydropower, while keeping some 32 megawatts as future development. The plan to develop small hydropower sources is of importance to the renewable energy development policy as it will also link with the energy conservation and environmental protection policy.

Small Power Producers (SPP). The Small Power Producer Policy is aimed to encourage and promote private enterprises in the generation of power from renewable energy, such as solar, wind, geothermal and agricultural and industrial wastes. Efficiency of energy production in industrial plants in the form of cogeneration where heat and power are simultaneously generated would increase considerably. Excess power not being used in the factories will be sold to the grid. The policy to buy power from SPP and feed them to the grid at a just rate would help factory owners in earning extra income and encourage the utilization of energy from waste efficiently, hence reducing the use of conventional energy. This policy has contributed to the energy conservation and environmental protection policy as well.

4. CURRENT STATUS OF RENEWABLES IN THAILAND'S ENERGY MIX.

Thailand is in the initial stages of introducing renewable energy into the country's total energy mix. The Department of Energy Development and Promotion (DEDP) reported that the total production of renewable energy namely fuel wood, paddy husk and bagasse, in 1993 were 17.7 Mtoe , an increase of 8.9% over the previous year and accounted for 51.9% of the total indigenious energy production.

4.1 Energy from Biomass. In 1994, Thailand consumed 10.3 million tons of firewoods and 6.5 million tons of charcoal for domestic cooking purposes in rural areas and small - scale rural industries. Baggasse's consumption by the sugar industry was 15 million tons. Rice husks combined with other agricultural residues were estimated at 46.6 million tons, as used mainly in the rice Mills throughout the country.

It has been estimated by the DEDP that each year, the country generates as much as 5.1 million tons of rice husks, 35 million tons of straws, 12.6 million tons of baggasse, 1.0 million tons of corn cobs, 1.8 million tons of cassava plants and 0.6 million tons of other agricultural residues respectively.

Other agricultural crops can be processed into liquid fuels. For example Methanol derived from sugar care and cassava. In addition, Thailand has some 5.8 million cows, 4.9 million water buffaloes and 4.7 million pigs and the excretion (dung) generated from these animals could be turned into biogas, giving energy equivalent to 27.2 million KCAL/year.

For the case of cassava where the country is faced with the surplus production every year, the House Committee on Energy in 1995, commissioned a study to use cassava chips and pulverised cassava as solid fuels for chain-stokered furnaces and burners respectively. It has been found that cassava as a solid fuel, has a much better combustion quality than the country's traditional lignites. The only drawback is that it is more expensive to fire cassava than lignites and hence presently, is uneconomical to use as energy source for the electricity generation.

4.2 Energy from municipal wastes. Bangkok generates its municipal wastes of about 6,000 tons per day (t/d) as against 200 t/d in Chiangmai and Haad Yai and 100 - 199 t/d in Pattaya, Ubonraj thani, Udornthani, KhonKaen, Nakorn Srithammaraj and Phuket. By average, these municipal wastes register a calorific value of 1,160 KCAL/Kg. The first power plant utilising municipal wastes as fuel was supposed to be installed at Hang Dong, Chiang mai but owing to resistance by the villagers, a new site must be selected.

4.3 Energy from alcoholic fermentation. With financial support provided by NEDO, The Japan Bioindustry Association and Thailand's DEDP have recently completed an experimental investigation involving development of a bio-technological process to produce alcohol from cassava. Even at the ideal, lowest cassava price of U.S.$. 22/ton which is unlikely to be accepted by cassava growers, the cost of production is U.S.$. 0.40/litre, rendering alcohol from cassava more expensive than the petroleum-derived fuel oils.

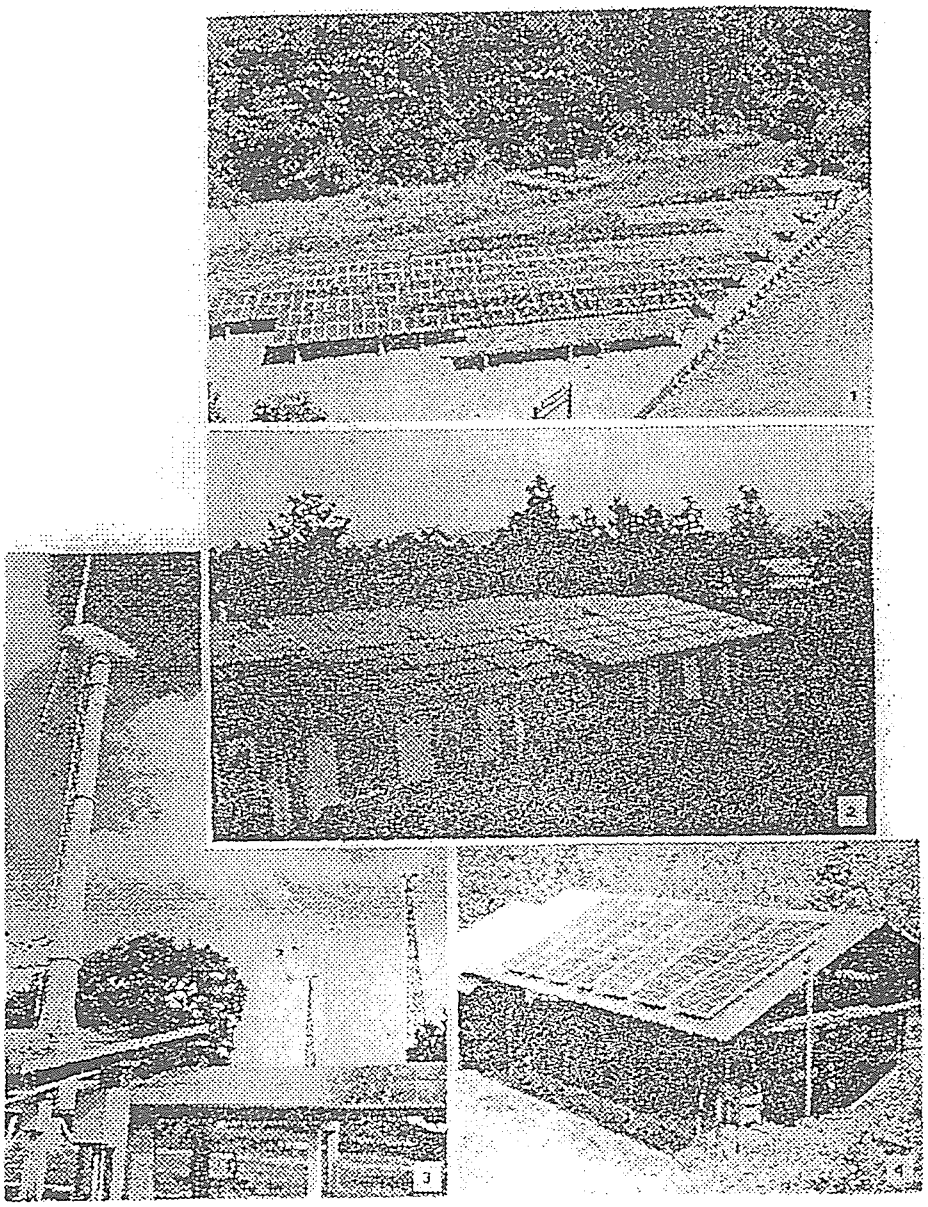
4.4 Energy from Wind. Thailand is unfortunate to be situated in a geographical area where the wind speed, by an average of 4 m/s, is classified as low for use with wind-turbine generating sets. The Electricity Generating Authority of Thailand (EGAT) has long been experimenting with wind turbines for power generation. The site at Phuket island, with an average wind relocity of 5 m/s, has been installed with wind turbines whose electricity generating capacities varies from the smallest 0.83 kwe to the largest 18.5 kwe. The total combined capacity of 42.33 kwe has been installed and connected to EGAT's national grid. There is no further development being planned for using wind turbines in a larger scale.

4.4 Energy from the Sun. Three interest groups are considered involvled in solar PhotoVoltaic Conversion System (PV) in Thailand. These are users, local manufacturers/distributors and academic institutions, know as a photovaltaic working group. The group has been set up under the National Rosearch Council to help promoting a meaningful realization of PV technology in Thailand. The following table shows the PV status in Thailand where a total of 1,986 kw have been installed. Ninety eight percent of which are for traditional small lighting, water pumping and radio communication in remote areas not yet served by distribution grid. The remaining two percent are for grid connected experiment.

Table 1. PV Status in Thailand

USERS / APPLICATIONS	PEAK KILOWATT (kWp) INSTALLED											
	U&I	EGAT	MOH	MOE	MOIN	MOD	MOI	DEDP	PEA	TOT	VH	ETC
WATER PUMPING	3					150	347					
STAND-ALONE ELECTRICITY FOR REMOTE VILLAGE									160			10
BATTERY CHARGING STATION	2						536	222				
TELECOMMUNICATION REPEATER		8				10				312		30
REMOTE PRIMARY SCHOOL				65								
REMOTE HEALTH CARE			6								10	5
HYBRID/GRID INTERFACE		44										
NAVIGATION AID		8										10
MISCELLANEOUS : TV., LIGHTING AQUARIUM FARMING, ETC.	8	10			15							15
TOTAL	13	70	6	65	15	160	883	222	160	312	10	70
GRAND TOTAL	1986											

U&I = UNIVERSITY AND INSTITUE
EGAT = ELECTRICITY GENERATING AUTHORITY OF THAILAND
MOH = MINISTRY OF HEALTH
MOE = MINISTRY OF EDUCATION
MOIN = MINISTRY OF INDUSTRY
MOD = MINISTRY OF DEFENSE
MOI = MINISTRY OF INTERIOR
DEDP = DEPARTMENT OF ENERGY DEVELOPMENT AND PROMOTION (FORMER : NEA)
PEA = PROVINCIAL ELECTRICITY AUTHORITY
TOT = TELEPHONE ORGANIZATION OF THAILAND
VH = VOLUNTEER HEALTH CARE MISSION UNDER THE PATRONAGE OF THE KING'S MOTHER
ETC = OTHERS INCLUDING PRIVATE SECTOR



1- PV 20 kW at Klong Chong Klum Hybrid with 20 kW Hydro,Grid Connected

2- PV 14 kW at San Kampaeng, Gred Connected

3- PV 8 kW at Phuket Hybrid with 42 kW WTGs, Grid Connected

4- PV Roof-Top 2.5 kW at San Kampaeng, Grid Connected

Figure EGAT's PV Grid Connected Demonstration Projects

PV is already competitive for some small applications like lighting, television and water pumping etc. in remote area. During the next several years, PV will be more acceptable in those remote communities which cannot be served by the rural electrification program. Should PV price continue to drop and its efficiency increased, and if the matters of energy situation and environment impact become to cause more concern (which is the likely trend), the wide-spread use of individual Roof-Top PV or even the central station grid connected version in some areas may become feasible by the turn of this century. Moreover, it is envisaged that Indochinese countries will increase their installation of PV facilities by foreign assistance. Thailand based export of PV panels to these countries should be expected. And it is hoped that this will help, in a small way, to promote PV industry in Thailand.

5. Conclusion.

Renewables such as agricultural and forestry wastes namely fire woods, charcoal, paddy husks, corn cobs, baggasse and animal wastes have seen used widely in rural households and small industries in rural areas. It is envisaged that Thailand will increase the role of renewables in the country's plan for energy mix in the near future. PV has a promising outlook as it is already competitive for some small applications like lighting, television and water pumping etc.

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SESSION 2

エネルギー、環境、廃棄物

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本稿のねらいは、経済活動から発生する廃棄物の範囲、その廃棄物が社会（公衆衛生、社会的アメニティ）および自然環境に与える影響を調べることにより、エネルギー部門の廃棄物管理をめぐる論争の背景を説明することにある。この目的のため、廃棄物の定義を広げ、固体廃棄物だけでなく大気・生物圏への放出物も廃棄物として含めることにした。本稿では、エネルギー部門および他の産業分野から発生する廃棄物の量をまず簡単に比較し、次に種々の発電について、それぞれの燃料サイクルによってどのような性質の廃棄物が生まれるかを調べる。これらの廃棄物が社会や環境に与える影響について検討するとともに、その損害を金額で定量化する方法について述べる。最後に、さまざまな廃棄物の流れの意義を論ずるのに、外部コストに関する最近の研究結果を使用する。

発生量に関しては、エネルギー部門は固体廃棄物の重要な発生源ではあるが、群を抜いているというわけではない。たとえば、ＯＥＣＤの報告書によると、１９９３年に日本のエネルギー部門から５７００万トンの廃棄物が発生したが、製造業からは１億４４００万トン、鉱業・採石から３５００万トンの廃棄物が発生している。これに対して日本の原子力部門から出たのは、わずか８７６トンの使用済み燃料である。しかし、エネルギー部門は、大気汚染物質（ＳＯｘ、ＮＯｘ、微粒子など）および温室効果ガスの最も優勢な発生源である。しかし、廃棄物の発生量そのものはそれほど重要ではなく、これらの廃棄物の流れが社会や環境に与える影響の方が重要である。

発電による社会および環境への影響を検討する際、全燃料サイクル（すなわち、一次採取、輸送、処理、転換、送電）にわたって発生する廃棄物を調べることが肝要である。これらの廃棄物が及ぼす重要な影響には、公衆衛生、職場衛生、業務災害、騒音、視覚障害、大気汚染物質による被害（農業、森林、生態系、漁場、原材料など）が含まれる。石炭、褐炭、石油、天然ガスおよび原子力発電についてそれぞれの燃料サイクルの影響に関する研究のため、欧州委員会の「ExternE プロジェクト」であげられた例を示す。

最後に、燃料サイクルのさまざまな影響と関連した外部コストの評価について報告する。これらは、ExternE プロジェクトならびに特に地球温暖化に関する最近の研究結果から引き出したものである。これらの研究結果は、本来予備的なものであり、かな

りの不確定要素を含んでいるが、各種発電の燃料サイクルの主要な影響の原因と相対的規模を適切に示している。また、化石燃料サイクルから出る他の放出物と比較した原子力の廃棄物の意義について論じる。

JAIF Annual Conference 1997
Session 2 - Managing Waste Products from Energy
Keynote Address

ENERGY ENVIRONMENT AND WASTE

(Dr George Marsh, Manager for Energy and Environmental Strategy, ETSU, AEA Technology, UK)

ABSTRACT

This paper aims to give context to the debate on waste management in the energy sector by examining the range of wastes stemming from economic activities and their impacts on society (e.g. public health, social amenity) and the natural environment. To achieve this a broad definition has been adopted for waste to include emissions to the atmosphere and biosphere as well as solid waste products. Starting with a brief comparison of the quantities of waste produced from the energy sector and other industrial areas, the paper goes on to examine the nature of the wastes arising from different electricity generation fuel cycles. The impacts on society and the environment, caused by these wastes are reviewed, and methods for quantifying the damage in monetary terms are discussed. Finally the results of recent studies of external costs are used to discuss the significance of different waste streams.

In terms of mass the energy sector is an important, but not dominant, source of solid waste. For example OECD reports that in 1993 the Japanese energy sector produced 57M tonnes of waste compared to 144M tonnes from manufacturing industry and 35M tonnes from mining and quarrying. In contrast the Japanese nuclear sector produced only 876 tonnes of spent fuel. The energy sector is, however, a dominant source of atmospheric pollutants (i.e. SO_x, NO_x, particulates, etc.) and greenhouse gases. However, quantity of waste is not significant in its own right, it is the impact of these waste streams on society and the environment which is important.

When considering the social and environmental impacts of electricity generation, it is essential to examine the wastes produced over the full fuel cycle (i.e. primary extraction, transportation, preparation, conversion and transmission). Important impacts arising from these include public health, occupational health, occupational accidents, noise, visual intrusion and damage due to atmospheric pollutants (e.g. agriculture, forestry, ecosystems, fisheries, materials). Examples, drawn from the European Commission's ExternE Project, are described for impact studies of coal, lignite, oil, gas and nuclear power generation fuel cycles.

Finally, estimates of the external costs associated with the various impacts of the fuel cycles are reported. These are drawn from the ExternE Project, and also recent studies directed specifically at global warming. Although preliminary in nature, and involving a significant range of uncertainty, these results give useful indications of the causes and relative magnitudes of the key impacts of the different power generation fuel cycles. The significance of nuclear waste in comparison to other emissions from the nuclear and fossil fuel cycles is discussed.

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This paper aims to give context to the debate on waste management in the energy sector by examining the range of wastes stemming from economic activities and their impacts on society and the natural environment. To achieve this a broad definition has been adopted for waste to include emissions to the atmosphere and biosphere as well as solid waste. Starting with a brief comparison of the quantities of waste produced from the energy sector and other industrial areas, the paper goes on to examine the nature of the wastes arising from different electricity generation fuel cycles. The impacts on society and the environment, caused by these wastes, are reviewed, and methods for quantifying the damage in monetary terms are discussed. Finally the results of recent studies of external costs are used to discuss the significance of different waste streams.

1. INTRODUCTION

Most forms of economic activity lead to the generation of waste. This is illustrated by data from OECD[1] which lists the large quantities of solid waste arising from different economic sectors across a range of member states (Table 1). On current trends waste production is set to increase further, as the developed economies continue to grow and developing countries undergo rapid expansion. This represents a major challenge to the global aim of moving to a more sustainable pattern of development. Waste streams constitute a significant loss of resources which could be re-cycled or used for other purposes (e.g. incineration for energy production).

Also on the theme of sustainable development, wastes may have negative impacts on society and the environment. For example the effects of air or water pollution on health, buildings, crops, forests and natural eco-systems; or reduced amenity from visual intrusion or emissions of noise. Such impacts may result from solid wastes, if these are not managed effectively, and also from the direct release of wastes (pollutants) to the atmosphere or biosphere. It is most meaningful to consider the impacts of a particular industrial area or process in an integrated manner, taking account of the effects of solid, liquid and gaseous wastes, rather than examining each in isolation. This is the approach taken in this paper.

With regard to the energy sector, Table 1 shows this to be an important source of solid waste. It is also the major source of atmospheric pollutants, including CO_2, NO_x, SO_2 and particulates. Tables 2 and 3 illustrate this for CO_2 and SO_2 emissions.[1]

Focusing on electrical power generation technologies, the waste emissions from these vary considerably depending on the fuel cycle involved. For example coal fired generation produces appreciable quantities of both solid and gaseous wastes, whereas gas fired generation produces much less solid waste, as well as negligible emissions of SO_2. Moreover, waste emissions may occur at different stages in the fuel cycles of alternative generation technologies. By example the solid waste from nuclear power generation mainly arises in the extraction and processing of uranium or in the processing of spent fuel. In contrast the emissions from renewable energy sources are mainly linked to the fossil energy used in their manufacture.

Consequently, in comparing the waste emissions from different power generation cycles, it is necessary to examine the full fuel (or life) cycle of each technology. Several detailed studies of this kind have been made.[2,3,4]

While life cycle studies will yield firm data on the waste emissions from different power generation technologies, this alone does not provide a basis for comparing their social and environmental impacts. This is because different wastes have different impacts, and the impacts themselves (e.g. health effects, crop damage, etc) are extremely variable in nature. In recent years considerable effort has been directed at the development of a consistent framework for the comparison of fuel cycles based upon estimates of their external costs. External costs are evaluations of the impacts on society and the environment caused by waste emissions. They are termed 'external' because these costs are not included in the market price of the electricity.

This paper aims to provide context to the debate on waste management in the energy sector by describing the results of a series of external costing studies. It begins by giving a brief review of the methodology for evaluating external costs and then outlines the results of studies of the coal, lignite, oil, gas, nuclear (PWR), wind and hydro power generation cycles. A separate discussion is given of the complex issue of global warming, and the paper concludes with a discussion of the most significant waste streams.

2. METHODOLOGY

External costs may be estimated by assessing the impact or damage caused or by evaluating the cost of abating the pollutants responsible for the damage. This paper concentrates on the damage assessment approach, which has been developed and applied to a range of electricity fuel cycles through the European Commission's ExternE Project.[5-9] The term 'fuel cycle' refers to the chain of processes involved in the generation of electricity from a particular fuel. Thus, as mentioned above, the assessment of the coal cycle should include impacts associated with plant construction, coal extraction, transport of coal and solid wastes and electricity transmission, as well as electricity generation itself.

The ExternE Project has developed a 'bottom-up' approach in which each stage in the fuel cycle is examined separately. Of course each stage may impose more than one burden on the environment (e.g. coal extraction results in gaseous emissions, particulates and water discharges in addition to solid waste), and indeed some burdens may have more than one impact (e.g. SO_2 emissions affect buildings, crops, forestry, natural eco-systems, etc). Consequently the approach leads to a large array of burdens/emissions and associated impacts. It is necessary therefore to make an initial assessment of the main burdens and impacts before going on to evaluate these quantitatively.

The estimation of the external cost associated with a particular burden/impact combination is made through the 'impact pathway' approach. An example of this approach is illustrated in Figure 1. The novel stages in this approach are the development of dose/response functions to assess the impacts, and monetary valuation methods to convert the impacts into external costs. It will be appreciated that detailed data drawn from a multi-disciplinary team is essential to implement this approach. In particular input is needed on:

- Technological performance and emissions data;
- Legal framework governing emissions, health and safety, etc;
- Specification of fuel used;
- Meteorological conditions affecting dispersion of atmospheric pollutants;
- Hydrological and geological conditions;
- Demographic data;
- Definition and condition of ecological sources;
- Definition of the value systems of individuals which determine the valuation of non-marketed goods (i.e. externalities).

Valuation of the impacts varies depending upon the nature of the damage done. When the impact affects a traded good such as agricultural crops or repairs to buildings, market prices can be obtained. When the impact affects non-traded items (e.g. natural eco-systems, visual intrusion, etc) expressed preference valuations are adopted.

It will be noted that the data, and consequently the results of this approach, are plant and location specific. To extend the approach to develop a marginal cost relationship for new power plant requires its application to a broader range of sites. This is part of the on-going work of ExternE. However, for present purposes it is sufficient to report the results from a series of site specific investigations.

3. RESULTS

The ExternE Project has considered the external costs from the following electricity generation fuel cycles:

- Fossil fuels (coal, lignite, oil and gas);
- Nuclear (PWR);
- Renewables (wind, hydropower).

3.1 Fossil Fuel Cycles for Electricity Generation

To date ExternE has produced preliminary results for case studies covering:

- hard coal power generation plants situated at West Burton (UK) and Lauffen (Germany);
- lignite power generation plant at Grevenbroich (Germany);
- two different oil power generation plant at Lauffen (Germany);
- natural gas power generation at West Burton (UK).

Note that these studies are based upon possible plants located at these sites, rather than existing plants. The generation technologies considered are typical choices for the relevant fuels in Europe in 1990. The coal and lignite plants use steam turbines with flue gas desulphurisation; the oil plant are gas turbines (GT) for light oil and combined cycle plant (CCGT) for heavy oil, and gas also uses combined cycle technology. Domestic sources of fuels were assumed for all cases.

Table 4 summarises the results for these fuel cycles, excluding global warming, which is discussed separately below. The levels of uncertainty on some costs are quite high, particularly for the larger damages, however, the relative results for different fuel cycles are reasonably robust.

The largest quantified impacts are on public health. These arise mainly from atmospheric emissions including primary and secondary particulates, SO_2 and O_3, most of which arise from the generation plant itself. Within this group the dominant impact was motility due to particulates, which accounts for 75% of the value in Table 4. However, this estimate is subject to particular uncertainty relating to two assumptions made in the estimation. Firstly it was assumed that there is no threshold below which fine particulates have no effect on health; secondly the full value of statistical life was applied to all deaths. The latter takes no account of the period of life lost, or the quality of that life. This is particularly important because these deaths are mainly amongst chronically sick people.

Other significant damage categories are Occupational Health (diseases and accidents) and materials damage. The former relates to accidents and routine exposure to hazardous substances, noise and physical and mental stress. Not surprisingly it is greatest with deep coal mining through accidents and exposure to air pollutants including dust and radon. Material damage is caused mainly by acid emissions. The values presented are based on the cost of repair to utilitarian buildings, with no allowance for aesthetic effects on historic buildings. In this sense the estimate may be an under-valuation. Impacts which have not been analysed due to their complexity and a lack of data are those concerned with natural eco-systems and fisheries.

3.2 Nuclear Fuel Cycle

The fuel cycle studied was the use of enriched uranium in a pressurised water reactor (PWR), with subsequent fuel reprocessing. All stages of the fuel cycle were located in France and included mining and milling of uranium, conversion to uranium tetrafluoride, enrichment, reactor irradiation, reprocessing, waste treatment and disposal. Disposal of low and intermediate level waste was to existing French facilities whilst vitrified high level waste was to be deposited in a hypothetical location.

The ExternE Project has focused on the impacts arising from normal operation. The emphasis has been on radiological human health effects resulting from exposure to radioactivity, considering both the public and employees. Eco-system impacts have not been examined because these were considered to be of low priority during normal operation.

Nuclear fuel cycle impacts are particularly complex because they have a wide spatial range and timescales. Consequently the results have been divided into local, regional and global, and classified as short-term (< 1 year), medium-term (1-100 years) and long-term (100-100,000 years).

The undiscounted results of this study are presented in Table 5. Without discounting for the timing of impacts, public health effects account for 94% of the 0.35 Yen/kWh estimated costs. The remaining 6% is occupational impacts, which are essentially non-radiological accident injuries.

There are some particularly complex issues to be considered when applying these results:

- Firstly the applicable discount rate is crucial since it will be noted from the table that 80% of the external costs arise over the long-term. With a discount rate of 3% the external costs are reduced to ~0.01 Yen/kWh. Moreover the main contributor to these costs ceases to be reprocessing and becomes the short-term areas of reactor construction, reactor operation and uranium mining and milling.

- 91% of the non-discounted costs are due to global impacts. This arises through the methodology which sums very small doses over 100,000 years and across a world population. The usefulness of monetary valuation of this type of impact assessment needs further consideration.

Not withstanding these issues the results are useful, on a comparative basis, to show the significance of the waste streams arising from the fuel cycle. Neither low/intermediate or high level wastes make a significant contribution to external costs. This reflects the design performance of both the waste forms and the planned storage and disposal conditions.

It should be noted that the study has not considered the potential impacts of releases from accident conditions, nor has it considered deliberate damage to facilities or malicious use of nuclear materials. Clearly these represent major issues for the nuclear fuel cycle.

3.3 Renewable Energy Sources

To date the ExternE Project has studied the wind and hydro fuel cycles. Wind farms have been assessed at two locations in the UK; a small development at Delabole in south-west England and a large project of over 100 turbines on open moorland in Central Wales. The study of the hydro-cycle covered two contrasting projects; a major extension (500 MW) to an existing hydropower scheme in south-west Norway and a small scale (20 MW) system on the La Creuse river in central France.

Results from these studies are summarised in Table 6. The major impacts of the fuel cycles are on human amenity - noise, visual effects and impacts on recreation. Valuations are highly site specific and targeted studies have been implemented to do this for the Norwegian and French hydropower sites. The UK studies used results from other locations, which increases the potential uncertainty over the results.

With the exception of human amenity the other significant externalities of renewables are linked to their manufacture and construction. This accounts for the comments in Table 6 on acidic emissions and greenhouse gas releases.

4. GLOBAL WARMING

The methodology for evaluation of the external costs of global warming is less advanced than for other impacts, and presents a range of key problems:

- the climate models for estimating the magnitude of global warming have advanced considerably in the last decade, but there is still a significant range of uncertainty over the size of the warming effect;
- estimations of the impacts of climate change (e.g. agriculture, water resources, biodiversity, coastal protection, etc) are subject to great uncertainty;
- the release of greenhouse gases and the impact of climate change is temporally separated, and the impact persists for many years;
- the extent of greenhouse gas releases is dependent on the future global path for economic and social development. For example the future could follow a 'business as usual' pattern or a more interventionist approach may be followed aimed at reducing greenhouse gas releases;
- the value placed upon both traded and non-traded goods will depend upon future economic development. For example the value placed on biodiversity is likely to be higher in an interventionist future driven by concerns over the environment and a desire for sustainable development;
- the marginal impact cost of greenhouse gas emissions from a new power plant will depend on the plants emission per kWh generated, and upon the future scenario in which it operates. Thus a coal plant without CO_2 sequestration, operating in a future with low CO_2 emissions, will have a lower impact cost than if it was operating in a future with higher emissions;
- because the impacts of global warming are time dependent the issue of discount rate is crucial to the valuation of the impacts. The appropriate discount rate to be applied is subject to much debate.

Detailed discussion of these major issues is beyond the scope of this paper. Needless to say, because of these complexities and the shortage of appropriate data, any estimates of the external costs of particular fuel cycles are subject to considerable uncertainty. However, some recent estimates from a study sponsored by the IEA's Greenhouse Gas R&D Programme[10] facilitate comparison with the other external costs reported in this paper. This study has implemented a bottom-up approach, considering individual impacts on a regional basis, to build up an aggregate estimation. These are listed in Table 7. The scenarios consider two possible futures, 'non-intervention' is essentially trends continued while 'intervention' considers some positive action to reduce greenhouse gas emissions. The three estimates given for each technology are an attempt to give high, low and median values for each step in the analysis of individual impacts and costs. The high and low values have no statistical significance, but represent an attempt to indicate the range of uncertainty in the costs.

The range of costs reported reflects the range of uncertainty still attaching to the estimation of climate change impacts and their costs. However, it should be noted that the median values, which represent current 'best estimates' are comparable in magnitude to the other external costs reported previously. The negative values represent situations where there is an estimated positive benefit from global warming. This arises when the benefits in terms of energy saving (reduced heating) outweigh the negative impacts. The median values are also reasonably in line with previous estimations of climate change impacts.[11-14]

No attempt has been made to calculate the external costs of climate change attributable to the nuclear and renewables fuel cycles. However, these will be substantially less than those reported above, since these cycles give no direct emissions of greenhouse gases.

5. DISCUSSION AND CONCLUSION

This paper has set out to give context to the debate on waste management and the environmental and social impacts of energy supply and utilisation. To do this on a consistent and comparable basis it has described the concept and approach to the costing of external impacts, and reported the results of recent studies. These have covered fossil, nuclear and renewable fuel cycles, and impacts affecting environmental and social factors. The paper has drawn heavily on the ExternE study which is sponsored by Directorate General XII of the European Commission. Costings of the specific impacts of climate change have been drawn from work of the IEA's Greenhouse Gas R&D Programme.

Setting aside climate change, the costing results have shown the coal and oil fuel cycles to have external costs of 1-2 Yen/kWh. Gas fuel cycle costs are about an order of magnitude less than this. Nuclear fuel cycle costs are also lower at about 0.3 Yen/kWh, and would be even less if some discounting was applied to the long-term global impacts. Not surprisingly the external costs of renewable energy fuel cycles are relatively low 0.1-0.3 Yen/kWh, and are mainly linked to social impacts (i.e. noise, visual intrusion, etc) rather than environmental impacts.

With regard to climate change, all the fuel cycles contribute to some extent on a life cycle basis. This is because some fossil energy is consumed in the manufacture of nuclear and renewable plant. However, the impact attributable to fossil cycles is substantially higher. The external costs of climate change are subject to the greatest uncertainty, but best current estimates suggest this should be of the order of 0.3-1.0 Yen/kWh for natural gas power generation and 0.6-1.7 Yen/kWh for coal.

It is noteworthy that for all the fuel cycles reviewed, solid waste has not figured as a major source of environmental or social impact. This is probably because most of this waste is well managed in the energy sector. Indeed some wastes (e.g. power station ash) have market worth for use as building or road construction materials. It could be argued that the potential impacts of solid waste arising from power generation fuel cycles have been avoided by good management practice. In other words the potential impact costs have been 'internalised'.

One final observation is that the nuclear fuel cycle external costs were calculated on the basis of normal operation. Clearly accident conditions could lead to much higher external costs. It might be argued that the present public resistance to nuclear, including waste management and disposal, is linked to a perception that safety is not so great as is indicated by engineering analysis. In other words public perception of the external costs is greater than analytical estimates indicate. Since external costs are fundamentally linked to the social values placed on non-traded goods, these 'perceived external costs' may well be a true reflection of the costs which the public attribute to nuclear fuel cycle operations; in terms of anxiety for example. The corollary is that the perceived costs can be reduced if ways can be found to reduce this anxiety.

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Note

The values quoted for external costs have been converted from original currencies to Yen to facilitate comparison and discussion. An exchange rate of £1 = 196 Yen was used for this. Reference should be made to the original texts if there is a need to apply the values given.

Figure 1

The Impact Pathway Approach to Estimating External Costs

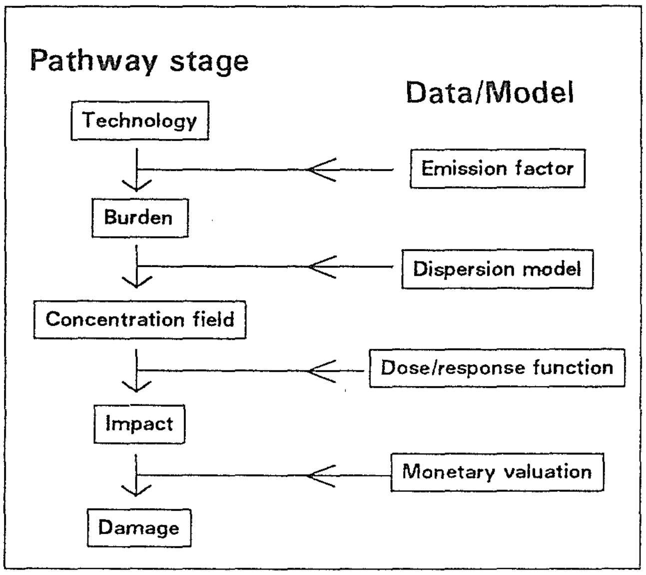

Table 1

SOURCES OF SOLID WASTE IN 1990 (Ref 1)
(k tonnes/year)

	Agriculture	Mining	Manufacturing Industry	Energy Production
JAPAN	77,390	34,000	150,388	54,983
USA*	165,821	1,541,850	760,000	1,093,039
FRANCE	400,000	75,000	50,000	N/R
GERMANY**	N/R	17,787	79,834	29,858
UK	80,000	108,000	56,000	13,000

* 1985 data
** West Germany only
N/R Not reported

Table 2

SOURCES OF CO_2 EMISSIONS IN 1993 (Ref 1)
(m tonnes/year)

	Transport	Energy Transformation	Industry	Other
JAPAN	244	384	297	170
USA	1490	2128	694	727
FRANCE	133	41	86	109
GERMANY	185	370	153	207
UK	139	203	82	125

Table 3

SOURCES OF ATMOSPHERIC EMISSIONS OF SO_X IN 1992 (Ref 1)
(k tonnes/year)

	Transport	Electricity Generation	Industrial Combustion	Industrial Processes	Other
JAPAN*	199	192	425	N/R	60
USA	958	14,371	3337	1919	37
FRANCE	155	330	250	182	304
GERMANY	96	2913	541	N/R	346
UK	118	2428	734	19	195

* 1989 data
N/R = not reported

Table 4

ESTIMATES OF EXTERNAL COST FOR FOSSIL FUEL CYCLES
(Yen/kWh)

Damage Category	Coal (UK)	Coal (D)	Lignite (D)	Oil (D) GT	Oil (D) CCGT	Gas (UK)
Public Health	0.6	1.8	1.4	1.6	1.4	0.1
Occupational Health						
- diseases	0.01	0.04	NQ	NQ	NQ	NQ
- accidents	0.1	0.3	0.01	0.07	0.04	0.01
Agriculture	0.004	0.003	0.003	0.006	0.003	NQ
Timber	0.0006	0.001	0.0006	0.002	0.001	Neg.
Marine eco-systems	Neg.	Neg.	Neg.	0.03	0.03	0.0001
Materials	0.1	0.03	0.01	0.04	0.03	0.008
Noise	0.03	NQ	NQ	NQ	NQ	0.004

NQ = not quantified
Neg. = negligible

Table 5

ESTIMATES OF THE EXTERNAL COSTS FOR A PWR BASED NUCLEAR FUEL CYCLE
(m Yen/kWh)

RANGE	TIMESCALE Short	Medium	Long
Local			
Mining	1	4	0.04
Conversion	0.08	0.04	6×10^{-4}
Enrichment	0.1	10^{-4}	4×10^{-4}
Fabrication	0.1	0.1	Neg.
Construction	4	0	0
Generation	1	7	Neg.
Decomm.	0	3	0
Reprocessing	0.4	0.04	4×10^{-4}
LLW disposal	0	3×10^{-3}	3×10^{-4}
HLW disposal	0	Neg.	4
Transport	0.06	0.06	0
Sub Total	**10**	**14**	4
Regional			
Mining	0	3	0.03
Conversion	0	Neg.	3×10^{-4}
Enrichment	0	Neg.	1×10^{-4}
Fabrication	0	3×10^{-4}	Neg.
Construction	0	0	0
Generation	0	0.4	Neg.
Decomm.	0	0	0
Reprocessing	0	1	0.3
LLW disposal	0	0	0
HLW disposal	0	0	0
Transport	0	0	0
Sub Total	**0**	4	**0.3**
Global			
Mining	0	0.003	0
Conversion	0	Neg.	0
Enrichment	0	Neg.	0
Fabrication	0	Neg.	0
Construction	0	0	0
Generation	0	4	42
Decomm.	0	0	0
Reprocessing	0	28	282
LLW disposal	0	0.01	0.7
HLW disposal	0	0	0
Transportation	0	0	0
Sub Total	**0**	**32**	**324**

Neg. = $<10^{-4}$ mYen/kWh

Table 6

ESTIMATES OF THE EXTERNAL COSTS OF RENEWABLE ENERGY FUEL CYCLES
(mYen/kWh)

Damage Category	Wind Turbines		Hydropower	
	S-W England	C. Wales	Norway	France
Noise	141	10	Neg.	Neg.
Visual Amenity	NQ	NQ	282*	NQ
Acidic Emissions	8% of coal fuel cycle		NQ	NQ
Greenhouse Gas Emissions	1% of coal fuel cycle		NQ	NQ
Public Accidents	13	13	NQ	NQ
Occupational Accidents	42	42	Neg.	7
Eco-system Impacts	Neg.	Neg.	282*	NQ
Agricultural Impacts	Neg.	Neg.	1	Neg.
Forestry Impacts	0	0	Neg.	Neg.
Impacts on Water Supply	0	0	1	NQ
Recreational Impacts	NQ	NQ	282*	NQ
TOTAL	**196**	**65**	**282**	**NQ**

* Aggregate value for visual amenity, eco-system impacts and recreational impacts
NQ = not quantified
Neg. = Negligible

Table 7

ESTIMATES OF THE EXTERNAL COSTS OF CLIMATE FOR PARTICULAR POWER GENERATION TECHNOLOGIES
(Yen/kWh)

FUEL CYCLE	SCENARIO Intervention	 Non-Intervention
Natural Gas (CCGT)		
High	33	67
Median	0.36	1
Low	-0.007	0.003
Coal (PF+FGD)		
High	55	113
Median	0.6	1.7
Low	-0.01	0.005

* Zero discount rate

英国における廃棄物管理の展望

英国原子力産業放射性廃棄物管理会社（ＮＩＲＥＸ）社長
Ｍ．フォルガー

英国では１９８７年以来、深地中処分に関連する作業責任を、廃棄物処理機関、廃棄物発生者、安全規制当局、および政府の間で明確に区分する必要があることが強調されている。また、科学者や他の利害関係者の理解を得る上で、科学的な調査結果と、処分場候補サイトの施設閉鎖後の安全性の予備的評価結果を公開することが必要条件となる。

これらは不可欠な要素だが、パブリックアクセプタンスの獲得・維持を保証するものではない。批判者たちは、脈絡や均斉を欠いた上で、特定の不確定性や問題を曲解する傾向があるので、そのような批判に対処する上で、開発目的を平易な言葉で地元のレベルから説明していくという、先を見越した方策が不可欠である。

有力な処分場サイトを特定するために、１９８７年以来ＮＩＲＥＸ社が行ってきた活動を紹介する。施設閉鎖後の安全性の観点から、有望サイトを特定・選定する上で考慮すべき要因をあわせて紹介する。

物理、化学、および天然からなる多重バリアによる封じ込めというＮＩＲＥＸ社の処分概念と、地質・安全関連の必要な研究を管理する上での依頼者主導方式の仕組みを説明する。

広範な深地中ボーリングおよび地球物理学的試験計画を通じて、イングランド北西部のセラフィールド近くの候補サイトが有望であることがわかった。地下水が飽和した硬岩が分布する同地域の地質学および水文地質学的な特性と、１９９５年９月から９６年２月にかけて行われた集中的な公開審査（公聴会）に提出された予備的な安全評価結果について説明する。今後計画されているモデリングおよびデータ分析の相互作用構造について述べ、セラフィールドにおいて提案されている岩石特性調査施設（ＲＣＦ：（通称）地下研究所）の役割を論じる。サイト閉鎖後に個人が受けるリスクを、より確実に評価することに焦点を当てることとする。

MANAGING WASTES: A PERSPECTIVE FROM THE UNITED KINGDOM

M Folger
Managing Director
UK Nirex

In the UK, work on deep disposal since 1987 has emphasised the importance of a clear division of responsibilities between the waste agency, waste producers, safety regulators and government. Another necessary condition for securing a measure of acceptance from the scientific community and other stakeholders has been open publication of scientific studies and preliminary post-closure safety assessments of candidate sites for a repository.

These factors have been essential but do not guarantee success in building and sustaining public acceptance. A pro-active policy in explaining developments in lay terms, from local level upwards, is essential to counter critics who tend to distort particular uncertainties and issues out of context and out of proportion.

Nirex work since 1987 to identify a potential repository site is described, with a summary of promise in terms of post-closure safety.

The Nirex disposal concept - containment based on multiple physical, chemical and natural barriers - is explained, together with the structure of a client-driven approach to managing the necessary geological and safety studies.

An extensive programme of deep borehole drilling and geophysical testing has established the good promise of a preferred candidate site near Sellafield in North-West England. The geological and hydrogeological characterisation of the saturated hard rock setting are an intensive public inquiry process which ran from September 1995 to February 1996. The interactive structure of the forward programme of modelling and data analysis are described, together with the role of the proposed Rock Characterisation Facility at Sellafield. The focus is on progressively firmer assessment of post-closure risk to individuals.

The 30th JAIF Annual Conference

8-11 April, 1997

Managing Wastes: A Perspective from the United Kingdom

Michael Folger, Chief Executive UK Nirex Ltd.

Introduction

Nirex has worked since 1987 to secure understanding and acceptance of the UK programme for deep disposal of radioactive waste. No country has found this task easy and despite our most recent setback, we continue to see two key disposal policy requirements:

- first, a clear separation of the responsibilities between the safety regulators, the waste producers and the waste disposer - under a clear Government waste management policy;
- second is the necessity for openness and independent peer review of the scientific conclusions which are safety critical. Nirex's 1995 publication of a preliminary safety assessment of a potential repository site in saturated hard rock - at Sellafield - was a world first and between 1988 and 1997 we have also published over 500 supporting technical reports.

Despite our planned rock laboratory falling foul of the "planning" law - what our American friends would call "zoning" law - we must continue to seek a permanent solution. That has been the key strand of media and political comment since the decision announced on 17 March. Waste producers require this for their waste and sustainable development requires us not to leave the problem for our grandchildren.

Nirex as implementor is responsible for repository development, including site selection and the preparation of safety cases. However, the nuclear industry - the main source of the wastes - has representation on our Board. Waste producer involvement is important so that they retain full confidence and understanding of the programme. With strong regulators applying checks and balances, that important feature can be secured without prejudicing the safety of disposal. The over-riding need is for public confidence and a necessary condition for that is waste producers' confidence.

Whilst a clear framework of responsibilities and a policy of openness are essential, they are not sufficient to ensure acceptance by the public. In the UK as elsewhere, the implementor must play a pro-active role in communicating with potential host communities, the academic community and other influencers or stakeholders. Of course, some of these groups have their own agendas, and too often their response to our efforts is to pick up every loose-end and blow it out of context. In that way they unnerve the public and politicians alike. But our stance can only be to build an honest position from which we can counter over-simplifications of complex issues. The resources and energy required for pro-active relationships is substantial.

Site Selection

Site selection for the UK deep repository commenced in 1987 and followed the three stage approach recommended by the International Atomic Energy Agency (Ref. 1):

(1) Regional Evaluation,

(2) Site Identification and

(3) Site Confirmation.

The first step in 1987 was a national public consultation exercise involving distribution of 50,000 copies of a report discussing issues relating to repository site selection (Ref. 2). This led to 2,500 responses which were used to influence the site selection approach.

Thirty per cent. of the land mass of the UK was identified as having characteristics favourable for a repository. Subsequently, 500 individual sites were identified and further reduced by consideration of population density and environmental sensitivity. A short-list of 12 options was then developed through a sequential sieving process in which expert advice was taken at each stage. Key factors in the process were the potential of the hydrogeological setting of each site, land ownership, waste transport and cost.

In 1989 the Nirex Board decided that we should investigate two sites, at Sellafield in Cumbria and at Dounreay in Caithness, Scotland. A factor in the decision was that both are adjacent to existing nuclear facilities and the local authorities and public showed a degree of understanding and support for nuclear activities. Other countries have sited repositories in such contexts or are considering doing so.

In 1991, following initial surveys and borehole drilling at the two sites, it was decided to concentrate further investigations at Sellafield. Whilst both sites had the potential to support an acceptable post-closure safety case, Sellafield has the advantage that some 60% of the wastes will arise there, and hence there would be significant savings in transport costs.

The Nirex Repository Concept

In common with other disposal agencies internationally, the Nirex disposal concept uses a multi-barrier containment system (Figure 1). Vaults, capable of taking something like 200,000m^3 of long-lived waste, would be excavated at depth in a stable geological setting. The wastes would be packaged in steel or concrete containers and be placed in the vaults which would then be backfilled with a cement-based material.

The concept makes use of both engineered (physical and chemical) and natural (geological) barriers:

- **Physical barrier** - the containers and grouts in which the wastes are packaged. Research indicates that a very high level of physical containment should be maintained for at least one thousand years, during which period around 99% of the radioactivity would decay.
- **Chemical barrier** - a cement-based backfill around the waste packages. It acts by conditioning groundwater to a high pH. It will operate for a period of at least 1 million years during which time 99% of the residual 1% of radioactivity will decay.
- **Natural barrier** - the geological setting - chosen to be stable and to have little natural resource potential.

Two of the key requirements of the geological setting, which dominate current risk calculations, are:

- to ensure that there are low flows of groundwater through the repository; and
- to ensure sufficient dilution of those very long-lived residual radionuclides that are eventually released from the repository, in order to limit concentrations in groundwater reaching the surface.

Science Programme

The scientific programme comprises three main components:

- research on the near field, engineered barriers and radionuclide transport processes in the geosphere and biosphere;
- site characterisation; and
- post-closure safety assessments.

The research programme on the near field has reached a mature stage and by 1999 it is intended that most aspects will have been completed, sufficient confidence having been gained in our understanding and models (Ref. 3). An extensive programme of research into the corrosion of steel containers indicates effective container lifetimes of between 9,000 to 16,000 years.

In respect of the chemical barrier, a sound database and associated modelling capability has been developed on the chemical performance of the backfill and consequent solubilities and sorption behaviour of radionuclides. Work to date indicates that the backfill should condition groundwater to a pH greater than 10 for a period well in excess of one million years which is sufficient to reduce substantially the solubilities of many key radionuclides.

Since 1989 an intensive programme of site characterisation for the repository at Sellafield has been carried out. Twenty seven deep boreholes (to depths of up to 2,000m) have been drilled and tested, complemented by over 10,000km of geophysical surveys (Figure 2).

The Sellafield repository concept envisaged the vaults to be at a depth of 750m in a low permeability volcanic tuff: the Borrowdale Volcanic Group (BVG). This is overlain by sedimentary rock, primarily more permeable sandstones. The groundwater system has three main components or regimes as illustrated in Figure 3:

- a shallow fresh water occurring throughout the area within the 'Coastal Plain Regime';
- a saline water occurring at depth towards the east of the area, within the 'Hills and Basement Regime' where the repository would be located; and
- a deep brine occurring at depth in the west of the area, within the 'East Irish Sea Regime'.

Hydrochemical testing suggests groundwater and solute ages in the BVG host rock of up to 1.5 million years, broadly consistent with the low permeability indicated by hydrogeological testing. By contrast, the Coastal Plain Regime is very active, flows being driven from high ground in the east towards the sea to the west.

The site characterisation and research programmes provide the basis for assessment of the post-closure safety performance of a repository. Development of confidence in that assessment is an iterative process in which a series of 'assessment cycles' is implemented in order to achieve confidence to underpin decisions on repository construction and operation.

The assessment cycles are a central driver of the Nirex programme. They provide an important input to refinement of the repository concept and design. Also, understanding of key safety sensitivities developed through the assessments enable the programme to be focused cost-effectively on addressing the most important remaining uncertainties.

Probabilistic Safety Assessment calculations of annual post-closure radiological risk to an individual are compared to the risk target of 10^{-6}. Figure 4 shows the expectation values of risk over time for a repository at Sellafield as calculated in the 'Nirex 95' assessment cycle (Ref. 4).

The calculations indicate that for the current, temperate climate groundwater discharge would be predominately to the sea (the lowest risk curve in Figure 4). The substantial dilution provided by the sea results in very low risks. For discharge to land (the top 3 curves), the expectation risk curve lies below the risk target and has two characteristic peaks:

- an 'early' peak, at around 20,000 years, due primarily to chlorine-36 which is not retarded by the chemical barrier; and
- a long-term and broader peak, at times greater than one million years, due primarily to the daughter products of uranium-238.

Wells, for domestic or agricultural purposes, can bypass some of the beneficial near-surface dilution processes that apply to very long lived radionuclides and potentially lead to higher risks than for the natural discharge pathway shown in Figure 4. This is a positive assessment, though we needed the RCF to remove uncertainties in it.

Programme Management

Individual elements of the scientific and technical programmes are managed by Nirex staff who direct the programme to ensure a high quality of work and that programme objectives are met. Results are assessed on a regular cycle to ensure focus on the issues which are most crucial to bottom-line safety performance. Close estimation of the costs of activities permits costs and benefits of different options to be examined. In managing the programme Nirex has therefore developed a substantial expertise in the requirements of all aspects of radioactive waste disposal: not only the scientific and technical aspects, but also the institutional and economic areas too.

We are sharing that expertise, not only with our immediate neighbours in the European Union, and Central and Eastern Europe, but also here in Asia and in Japan in particular.

Next Steps

The surface-based programme of site characterisation is scheduled for completion in 1997. Our planned next step was the development of a Rock Characterisation Facility (RCF) at Sellafield for *in situ* validation of models of the geology, hydrogeology and the transport and geotechnical characteristics of the rocks (Ref. 5). However, following refusal of "planning" permission for the RCF we have to re-evaluate our whole programme in consultation with Government. The core problem for the RCF decision was a procedural one - with the planning requirement looking for a higher degree of confidence from surface-based investigations than we saw as feasible. The planning inspector praised the high quality of our science work to date.

The waste will not go away. We still have a responsibility to dispose of Britain's radioactive waste in a timely and cost-effective manner. We hope there is a way in which the procedural issues can let us get on with that.

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UK Nirex Ltd

March 1997

FIGURE 1

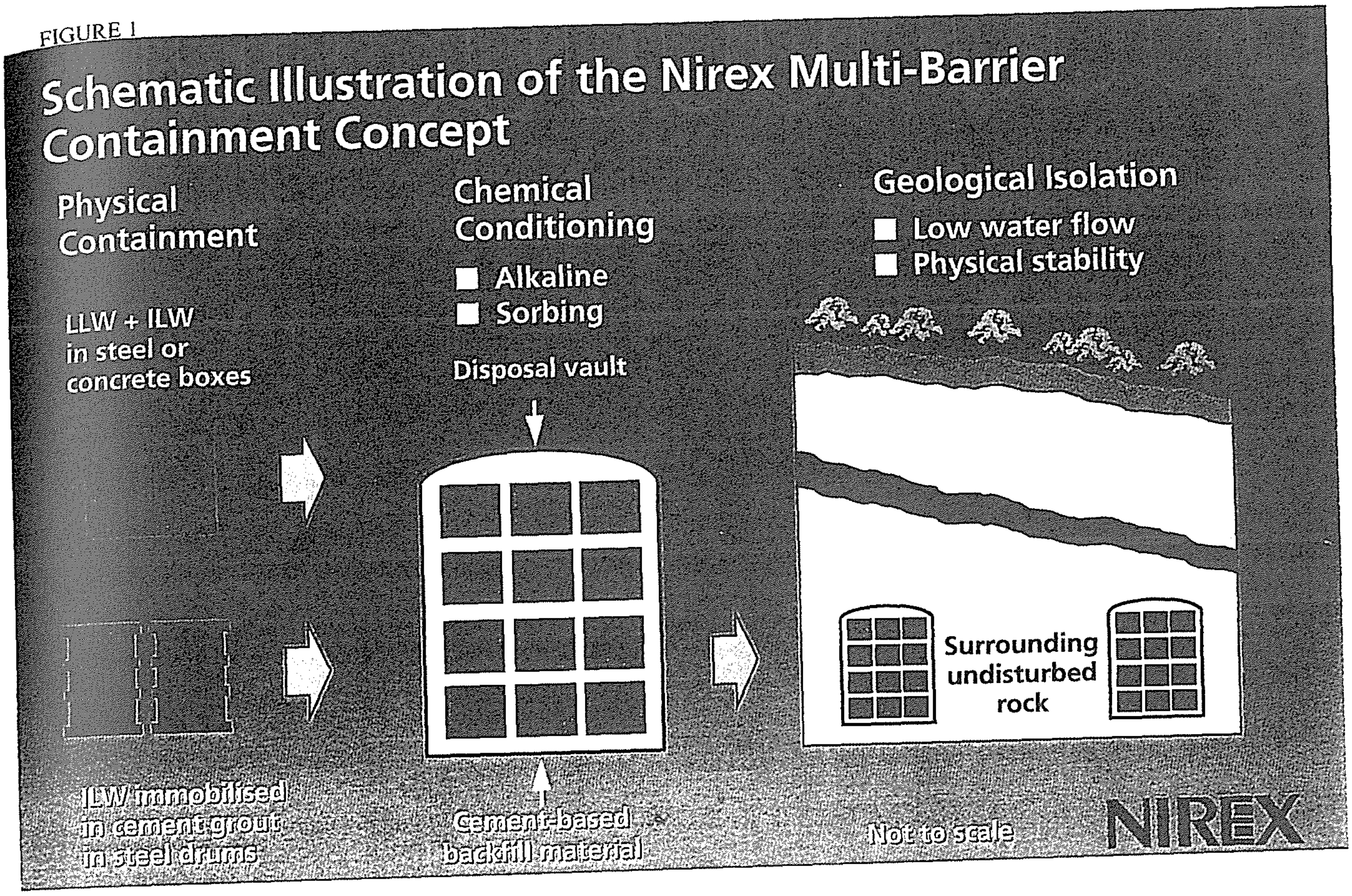


FIGURE 2

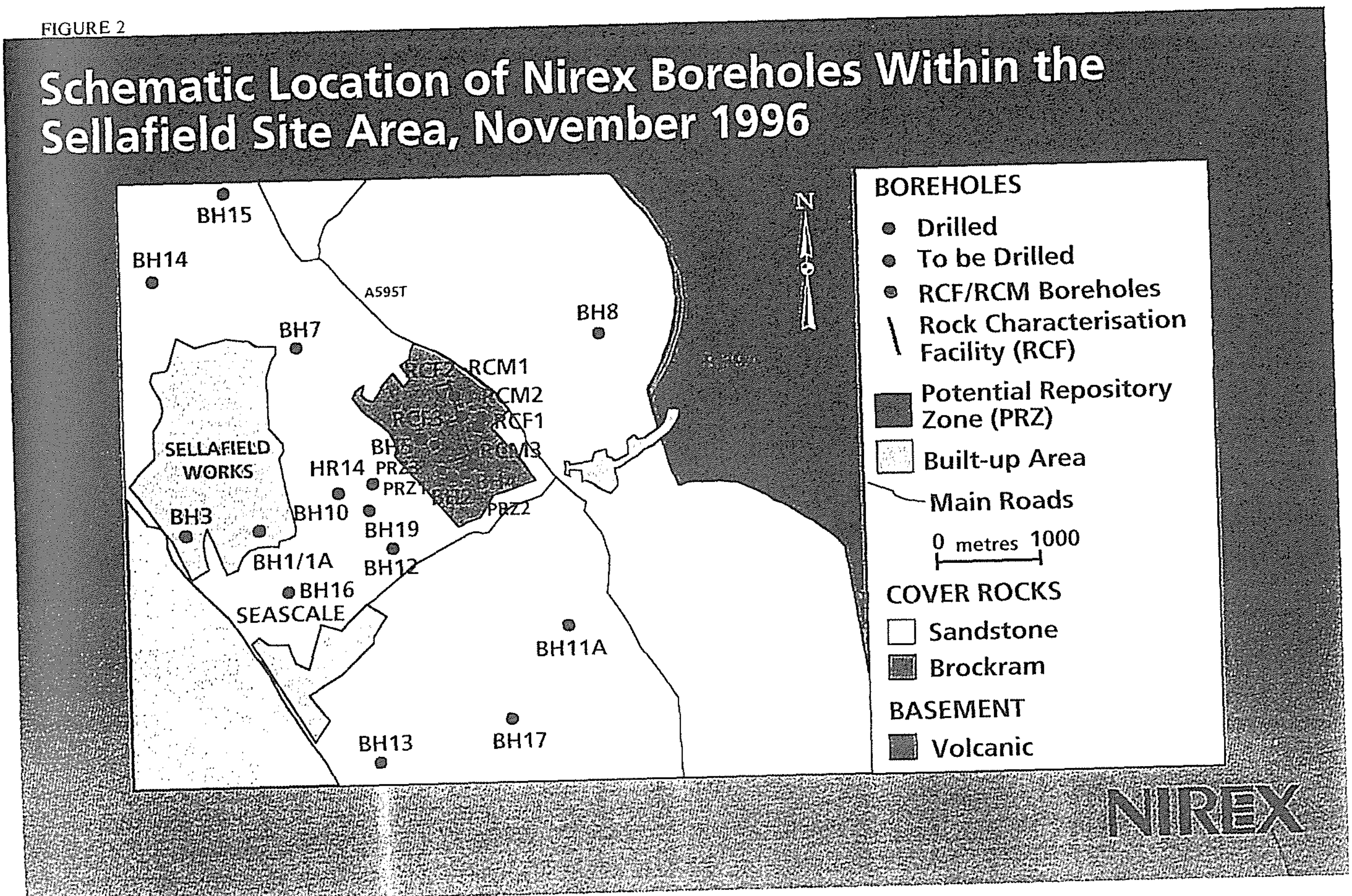


FIGURE 3

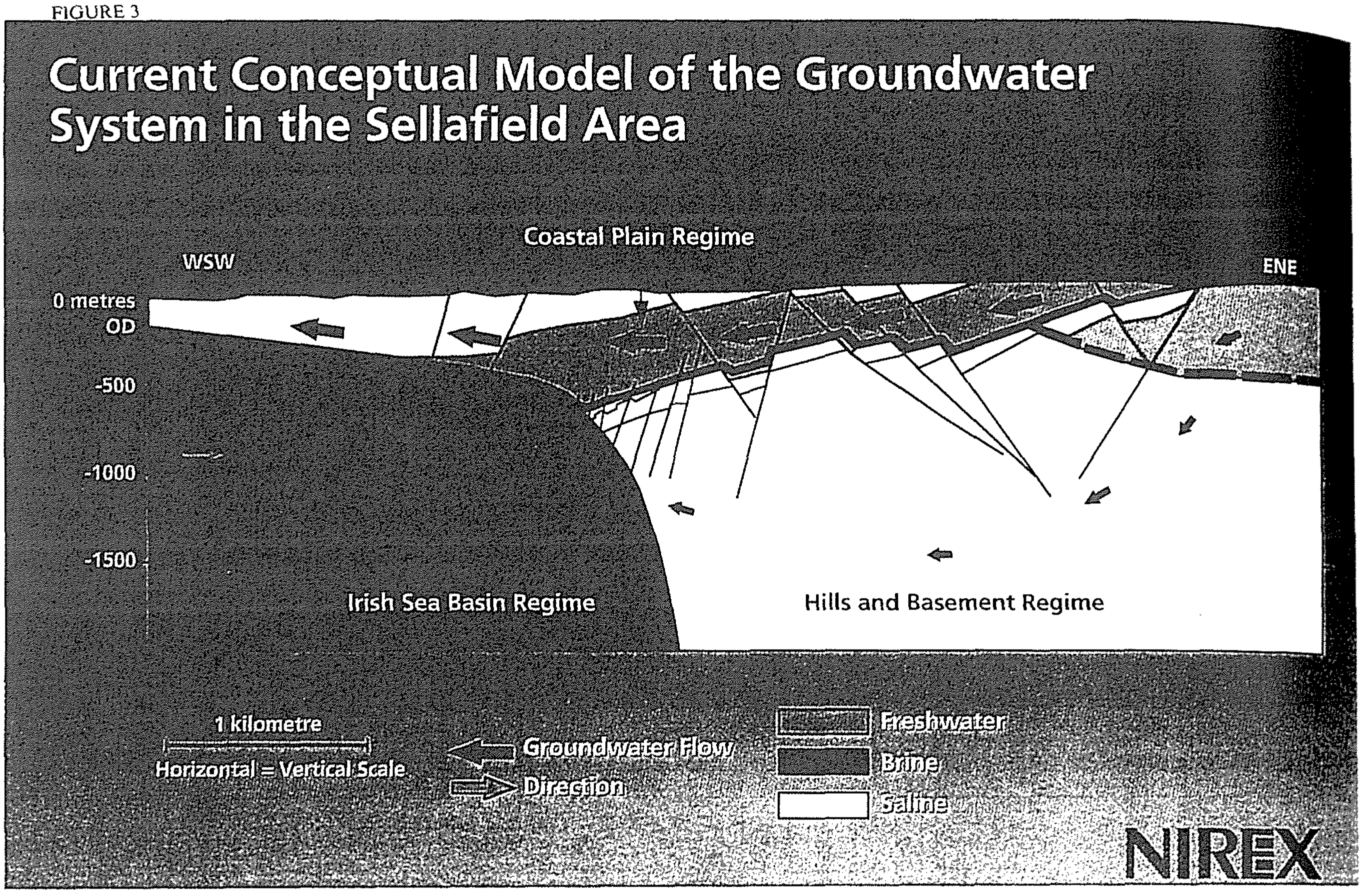
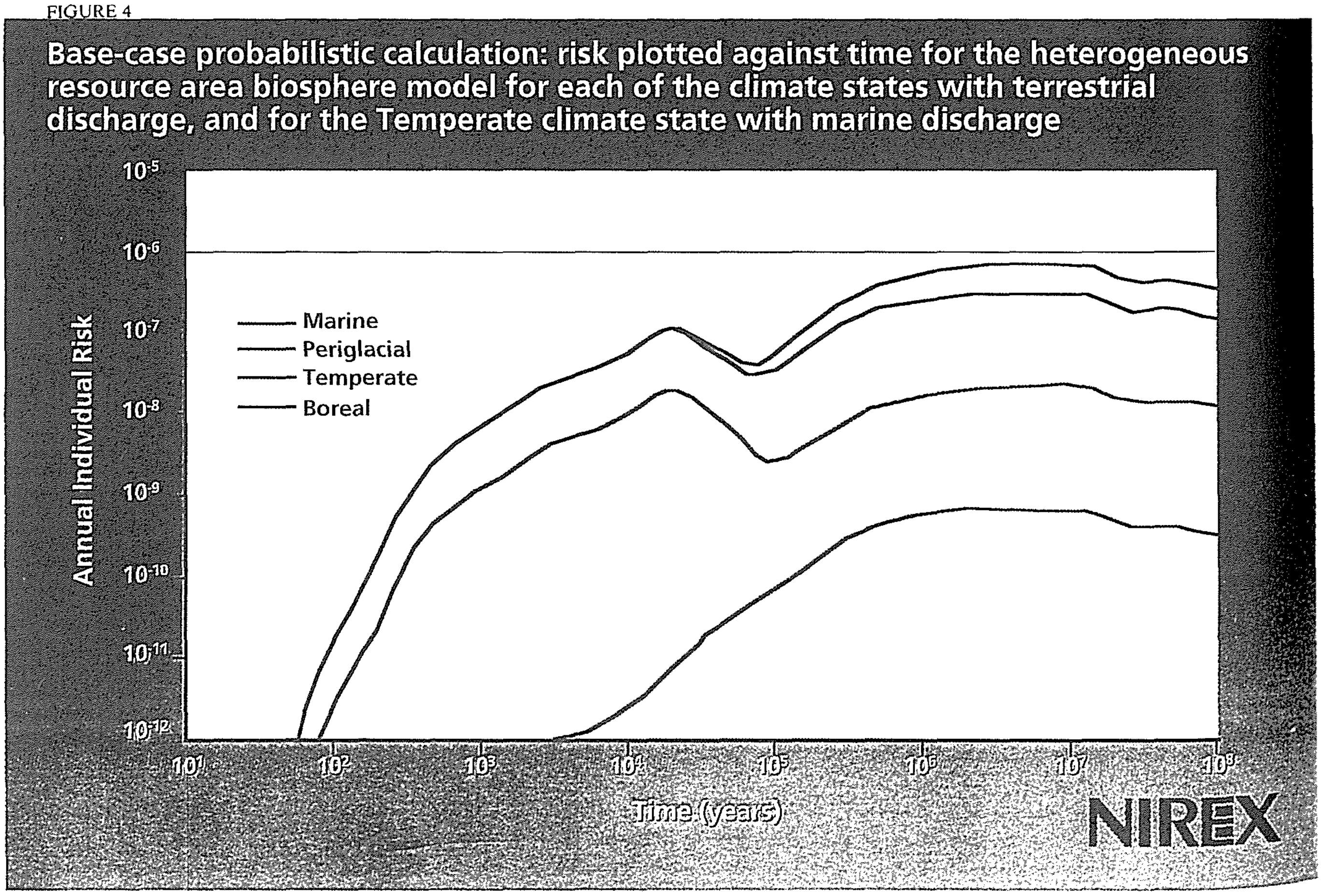


FIGURE 4



高レベル放射性廃棄物の処理・処分について

中島篤之助（元中央大学教授）

高レベル放射性廃棄物の処理・処分問題は核兵器用のプルトニウム生産とともに発生した，核エネルギー利用の開始以来の宿命的な問題であり，いまでもそれは巨大な負の遺産として残されたままである。１９５４年以来，いわゆる原子力平和利用が始まったが，高レベル放射性廃棄物の処理・処分問題は当初から意識されていたにもかかわらず，有効な対策の研究，開発そして実行は一日のばしに先送りされたまま今日に至っている。別紙資料１はこの問題の歴史的経緯を簡単に要約したものである。この要約は日本原子力学会誌所載の村野徹氏の「高レベル廃棄物地層処分の歩み－－主として米国の　歴史を中心に」と題する優れた解説に筆者が若干の補足を付け加えたものである。

旧ソ連のチエリャビンスクやウラルにおける深刻な環境汚染問題の発生は，核兵器開発という国家安全保障問題が優先された結果であり，環境汚染やそれに伴う住民の被爆などはまったく無視されたことを意味する。米国においてもこのような状況は基本的には変わらず，マンハッタン計画以来の庞大な高レベル廃棄物は，結局二重殻鋼製タンクに収容されたまま残されているのである。

１９７７年米国科学アカデミー（ＡＡＡＳ）は，国際学術連合（ＩＣＳＵ）にこの問題についての討議を行なうことを要請し，ＩＣＳＵは１９８３年に勧告を取り纏め，関係各方面にアナウンスした。ＩＣＳＵの提案は唯一の可能な処分方法として，地質学的に安定な岩体中に埋設するという「地層処分案」と，将来有望な可能性としての海底下処分を勧告している。わが国では原子力委員会が１９９４年の原子力開発利用長期計画で「処分に向けた総合的な取り組みの基本的考え方」を発表している。それをＩＣＵＳ勧告と比較すると，１）暫定貯蔵期間を何の根拠もなしに３０～５０年と切り詰めている（５０～１００年がＩＣＳＵ勧告）。２）海底下処分の研究をまったく無視している。３）使用済み核燃料の全量再処理という方針に固執している。その結果，４）外国への再処理委託に伴う返還廃棄物の割合が世界最大となっている。５）実施主体が未だに確定していない。など多くの問題点を含むのみならず具体的にはなにも行なわれていない状況にある。

別紙資料１．で示したように１９８０年以降地層処分を支える基本的技術として，

１）従来の科学が取り扱ったことのない超長期の安全評価の方法

２）敷地（サイト）特性調査技術の開発

が国際協力の最重要課題として進められ，ＯＥＣＤ－ＮＥＡ報告（１９９１年）としてまとめられてはいるが，それが実行されたわけではない。

土井和己氏も指摘するように[1)]，地層処分最大の問題は選定されたサイト中の水分の挙

動とそれに伴う放射能の移動の状況をしっかりした調査研究により把握することで，それには直ちに研究に着手しても１００年を要するであらうという事実を銘記せねばならない。

最大の問題はしかし社会的受容の問題であって，たとえば米国では核廃棄物政策法が成立したにもかかわらず，計画はまったく進展せず，その原因は「専門家と社会（一般市民）の間の正常な信頼関係が失われたことにある」とされている。フランスのバタイユ報告では「社会が廃棄物対策の最終決定を行なうべきである」として，民主主義の基本が改めて強調されている。わが国の原子力三原則とバタイユ報告を比較考量するならば，原子力三原則の先見性は明らかであり，いまこそ公開，民主，自主の精神に立ち戻らなければ問題の解決は不可能であらう。筆者はすでに１３年前に「放射性廃棄物は暫定貯蔵を考えよ」という一文をエコノミスト誌に発表している[2)]。その中で現在の再処理技術は「妄想」に過ぎず，技術的にも経済的にも未成熟であることを指摘しておいた。全量再処理という政策は誤りであり，したがって現在でもこの考えを変える必要はないと考えている。

註）　１）土井和己；放射性廃棄物；日刊工業新聞社（１９９３）
　　　２）中島篤之助；エコノミスト；１９８４．１２．２５

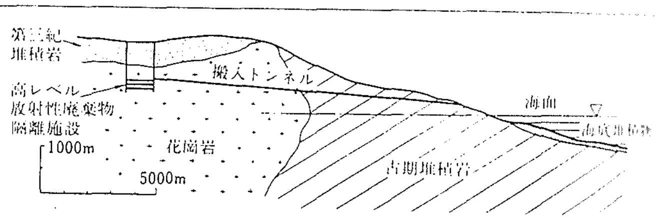


図 18　わが国での高レベル放射性廃棄物深層隔離に想定されうる概念の一例

高レベル放射性廃棄物を深層隔離する際天然バリアに要求される条件としては、天然バリアが安定しており，人工バリアの能力を十分に発揮させうるものであること，ならびに地下水を人工バリアに極力近づけないものであることです．深層隔離における天然バリアは岩石です．岩石の安定性を損なうもので最も重要なものが地殻変動ですが，その定量的な予測が困難な現在では，過去において長い期間安定していた岩石を天然バリアに選ぶこととなりましょう．このための長い期間としては，高レベル放射性廃棄物を隔離しておかなければならない年限を大幅に上回る年月が妥当でしょう．このような条件をみたす天然バリアとしては，活断層など現代に近い地殻変動の歴史を持つ地帯がまずのぞかれなければなりません．更に，堆積岩であれば第三紀（最も新しいもので 200 万年前の形成），ないし以前のもの，火成岩においても，第三紀ないしこれ以前に形成したものが妥当といえましょう．また，高レベル放射性廃棄物のように厚い遮へいを必要とする物体の搬入を考えるとき，海上輸送以外には考えられません．これらの条件が第一の選択肢となりましょう．これらの必要条件を備え，わが国でよくある地形，地質条件を頭に浮かべて高レベル放射性廃棄物の深層隔離の場を想定した場合，いくつもの想定が立てられますが，そのひとつを本図に紹介する絵としてみました．

筆者の想定，特にこのような地形・地質条件の所を選んだ理由を要約すると

1）わが国における高レベル放射性廃棄物隔離の最大の問題点は地下水ですが，国内で地下水のない地点は考えられません．一方，第三紀など新期堆積岩といわれているものの多くは火山灰などをふくみ，かつその多くは粘土化して不透水層ないし難透水層を形成しています．このため，一定の厚さを持つ新期堆積

高レベル放射性廃棄物の処理・処分の歴史的経緯

中島篤之助（元中央大学教授）

§簡単な歴史的経緯

Ⅰ．第一期　　１９４０年代～７０年代中頃

Ⅱ．第二期　　１９７０年代中頃～８０年代

Ⅲ．第三期　　１９９０年代～地層処分の実施開始前

§地層処分－第一期の歩み

（１）ＨＬＷ問題の発生－－米国の場合

イ．タンク貯蔵と漏洩－－軍用Ｐｕ生産炉の使用済み燃料の再処理廃液の貯蔵

ロ．プリンストン会議－－１９５５年９月，米国科学アカデミー（ＮＡＳ）
岩塩層への処分の提案

ハ．最初の原位置試験

プリンストン会議の結論に基ずき１９６５年オークリッジ国立研究所は，カンサス州ライオンズ岩塩鉱山で世界最初の野外試験－原位置試験－を開始。

ニ．ロッキーフラットＰｕ工場の火災

超ウラン元素で汚染された大量の放射性廃棄物が発生－－アイダホ州の貯蔵所に運ばれたが，州知事は「投棄場（Ｄｕｍｐｉｎｇ　Ｓｉｔｅ）」になることを恐れ，Ｇ．Ｓｅａｂｏｒｇと交渉し，８０年までにそれを撤去することを約束させた。－－早期に処分場サイトを決める必要が生じた。

（２）２つの計画の挫折

イ．最初の処分計画

ＡＥＣは１９７０年，ライオンズ・サイトを米国の最初のフルスケール処分場とすると発表。この発表は地元にも，研究者にも事前に知らされることなく，突然行なわれた。猛反対が起こり，７２年政府は計画を放棄した。

ロ．最初の長期貯蔵計画

１９７２年ＡＥＣはＲＳＳＦ（取り出し可能な地表施設で長期間貯蔵する）計画を発表。この計画も環境庁および社会の反対で，結局ＡＥＣは７５年このＲＳＳＦ計画を放棄。

（３）旧ソ連の場合

イ．チェリヤビンスクでは数百万キュリーの放射性廃棄物が未処理のままテチャ川に

放流され，１９５１年からはカラチャイ湖に放出～１億２０００万キュリーが蓄積。

ロ．ウラルの核惨事－－１９５７年

高レベル放射性廃液の貯蔵されていた施設が爆発し，約２０００万キュリーの放射能が環境に放出された。

§地層処分－第二期の歩み

（１）第二期の背景

「ＨＬＷの安全な処分が可能であるという見通しなしに，原子力の利用を継続することが果たして許されるか」という世論。

７６年のカリフォニア州法の成立－－原子力立地の条件として，ＨＬＷの安全な処分技術の存在を連邦政府が保証すること。

７７年のスウエーデンにおける条件法（Ｓｔｉｐｕｌａｔｉｏｎ　Ｌａｗ）の成立。原発の許認可に際し，ＨＬＷの処分の絶対的安全性の保証を求める。のちに絶対的は削除された。

このような世界的な世論の背景には環境問題の存在，あるいは環境や安全性に対する人々の認識の変化がある。

（２）技術面の進展－－本格的な研究報告の発表

イ．ＴＡＤ報告書（１９７６年）

ロ．米国地質調査所の報告書（１９７７年）

ハ．ＡＰＳ報告書（１９７８年）

ニ．Ｐｉｇｆｏｒｄ報告書

第一期の処分法が岩塩層といった特殊な地層中に廃棄物を埋設し，天然の地質環境のみに依存した方法であったのに対し，新しい地層処分では，

ａ．要求される地質環境条件を満たすものであれば，どのような地層であっても，地層処分の候補として研究の対象になり得る。

ｂ．地層処分に要求される廃棄物を隔離する性能は，天然の条件だけに依存するのではなく，工学的対策を含む１つのシステム，すなわち地層処分システム全体により達成されるという考え方が採用された。

ｃ．地層処分システムの性能が，長期にわたり満足できるか否かについては，合理的，科学的な評価が厳密に要求されることとなった。（安全評価）

１９８０年代になると，上述の骨格を支える基本的技術として，

◎長期的安全評価の方法

◎サイト特性調査技術の開発

が，国際協力の最重要課題として進められた。－－ＯＥＣＤ－ＮＥＡ報告（１９９１）が纏められた。

（３）制度面の進展

イ．核廃棄物政策法（ＮＷＰＡ）の成立

米国では，大統領が変わるごとにＨＬＷの貯蔵および処分の対策は変わっていた。このような状況を克服するためにＮＷＰＡ法が作られた。

ＮＷＰＡでは所見として，まず「ＨＬＷについての米国の過去３０年の対策は適切なものではなかった」とする反省を述べている点が注目される。

ＮＷＰＡでは◎政府機関（大統領を含む）の責任の分担　◎地層処分場のサイト選定の詳細な手順とスケジュール　◎処分対策等に必要な資金の調達　について詳細な規定が定められている。

ＮＷＰＡでは　◎地層処分場は２ケ所に設置する。（東部および西部）

◎第一処分場サイトは３つの候補サイトを詳細に調査して決定する。

ロ．ＮＷＰＡの改正

ＮＷＰＡは画期的な法律と考えられたが，現実はスケジュールどおりには進まなかった。１９８７年議会はＮＷＰＡ法を改正した。——ＮＷＰＡＡ

◎３つの候補サイトを平行して調査検討し，選定するのではなく，まず候補サイトの１つ，ユッカマウンテン・サイト（コロラド州，Ｙｕｃｃａ　Ｍｏｕｎｔａｉｎ　Ｓｉｔｅ）のみを調査し，適切ならばそれを処分サイトとして決定する。

◎第二処分場を設置する計画は中止し，改めてその必要性を検討する。

しかしこの改正はコロラド州および地域の人々に強い不公平感を残すこととなった。

（４）クライテリアの設定

「特定の地層処分システムが許容されるため，満足すべき一連の基準」

その基準の多くは，非常に長期の安全性というわれわれ社会に未経験の問題を含んでいる。

このようなクライテリアは１９８０年代に国際機関により検討され，その結果，ＩＡＥＡの基準（１９８９年）などが作成された。

以上第二期ではすべての面で進展があったにもかかわらず，しかも法的な裏付けのある米国ですら実際の進行は順調ではなかった。その原因は何処にあるのか？

§地層処分－第三期を展望する

（１）地層処分の再検討

たまたま１９９０年に米国とフランスで２つの報告書が公表された。どちらも過去の

歩みを深く分析し，将来への提言を行なっている。

イ．ＮＲＣ報告書（１９９０年）—米国学術研究会議

「高レベル放射性廃棄物処分の再検討」

米国のＨＬＷ地層処分のプログラムは何故順調な進展をしないのか，いかなる改善策があり得るのか」

地層処分という超長期の安全対策に含まれる基本的問題として

◎分析の限界（不確実性についての対応）

◎倫理および価値観の問題

◎モデリングとその有効性の詳細な分析

◎戦略的計画（柔軟で実際的な対策）の提案

これらの基本的項目について認識を誤ると，専門家と社会（あるいは，一般市民）の間の正常な信頼関係が失われ，地層処分のプログラムの進展に支障が生ずるとしている。

ロ．バタイユ報告書（１９９０年）

「高レベル放射性廃棄物の管理に関する報告書」

この報告の特徴は，専門家ではなく国会議員が中心になって作成している点である。フランスでは放射性廃棄物管理局（ＡＮＤＲＡ）による地下研究所設置のための現地調査の活動が，関係住民の強い反対に遭遇し，９０年１月，首相はその調査活動中止を決断した。この原因を明らかにし解決策を探るために，バタイユ報告が作られ，それを基礎に法律が制定され，第三期のプログラムが定められた。

この報告の基本的立場は，「社会が廃棄物対策の最終的な決定を行なうべきである」ということで，結論として次のような民主主義の基本が改めて強調されている。

ａ．責任と透明さと民主主義，この３つの言葉が，今後の廃棄物処分および原子力平和利用政策に関する施策を導くものでなければならない。

ｂ．原子力というエネルギー生産の洗練された手法には，開かれた決定手続きで臨むべきである。

地層処分第三期は一般市民の参加が不可欠となる時代であり，専門家と一般市民との間に，持続的な信頼関係が確立するか否かが，最も重要な鍵である。

以上は村野　徹氏の日本原子力学会誌の解説「高レベル放射性廃棄物地層処分の歩み——主として米国の歴史を中心に」を要約し，若干の補足を行なったものである。

第３０回原産年次大会
セッション２：エネルギーの廃棄物にいかに対処するか

「廃棄物問題と原子力」（要旨）

関西電力(株)　鷲見禎彦

人類の生存にとって、環境問題、即ち、廃棄物問題は死命を制する問題となりつつある。

廃棄物についての基本的考え方は、①発生量そのものの低減、②発生した場合も、リサイクル・再利用、③再利用できないものは、安全で生物環境に負荷を与えない処分、の３段階の考え方であるべきである。また、発生者の責任において、低減、再利用、処分を進めることも重要である。

そこで、廃棄物問題をエネルギー利用に適用して考えてみたい。

エネルギーの利用に伴う特有の廃棄物としては、二酸化炭素、ＳＯＸ、ＮＯＸ、放射性廃棄物、排熱などがある。

このうち、地球温暖化、酸性雨などの地球環境問題の観点から、二酸化炭素、ＳＯＸ、ＮＯＸなどの大気中への放出の削減の努力が続けられている。

原子力利用からの特有の廃棄物、即ち、放射性廃棄物については、取り出すエネルギーに比較して量は非常に小さくコンパクトで、技術的にも十分な安全な管理が可能であり、適切に処分できると考えている。

資源問題のみならず、廃棄物の観点からみても、化石燃料の消費を野放図に増やすことはできない。

従って、今後のエネルギー需給を確保していくためには、消費面では、節約、エネルギー利用の効率化、供給面では、再生可能エネルギーや原子力の重要性がますます高まると考えている。

原子力に前述の廃棄物の三段階の原則を適用して考えれば、原子燃料サイクルは、使用済燃料から有用なエネルギー資源であるウラン、プルトニウムと核分裂生成物を分離することにより、有用な資源は再利用し、廃棄物を適切に処分する方策として、この原則をまさしく踏まえたものであると言えよう。

廃棄物問題の視点からも、原子力は重要なエネルギー源であり、原子燃料サイクルによって持続続可能なエネルギー源となるものである。

Waste and Nuclear Power
(Summary)

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Global environmental problems, which are induced by wastes from human activities, may determine the fate of our planet and the survival of humankind. In addressing the problem of waste, waste management should consist of three steps:

1) reduction of the quantity of waste produced;
2) recycling or reuse of waste generated; and
3) safe disposal of waste which cannot be re-used.

It is also important that waste producers should be responsible for the reduction, reuse and disposal of the waste.

Following this concept, let us consider the problem of waste in connection with energy use.

Wastes arising specifically from energy production include carbon dioxide, sulfur oxides, nitrogen oxides, radioactive waste and waste heat. Among these, continuous efforts are being made to reduce the emission of CO2, SOX and NOX to mitigate global environmental problems such as global warming and acid rain. Regarding the wastes unique to nuclear power, that is radioactive wastes, it is extremely small amounts and compact volume and is technologically controllable; this allows it to be safely managed and properly disposed.

In view of maintaining healthy environment as well as securing energy supply, the consumption of fossil fuels cannot be allowed to increase limitlessly. Therefore, conservation and more efficient use of energy in terms of energy consumption and renewable energy and nuclear power in terms of energy supply will become more and more important.

The above-mentioned three steps of waste management can be well applied to nuclear power generation. Nuclear fuel recycling can be said to be the very means that enables useful resources to be reused, and wastes to be properly disposed. Namely, spent fuel reprocessing can separate uranium, plutonium and fission products, and useful uranium and plutonium are reused as fuel and fission products as high level radioactive waste are appropriately disposed.

In terms of waste management, nuclear power will play a more important role in the next century and nuclear fuel recycling will make nuclear power a sustainable energy resource.

ＯＥＣＤから見た放射性廃棄物管理

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高橋　誠

原子力施設では様々なタイプの放射性廃棄物が発生し、廃棄物の安全な管理を目指して、処理および安全な形態への調整、処分前の暫定貯蔵、環境への希釈放出と浅層または地下処分場での処分など、適切な方法や方策が開発されてきた。多数の低中レベル放射性廃棄物（ＬＬＷ／ＭＬＷ）用処分場が現在稼働しており、今後もこうした処分場がＮＥＡ加盟諸国で計画されている。

最近の活動は、暫定貯蔵される使用済み燃料の増大と、使用済み燃料の再処理によって発生するガラス固化高レベル放射性廃棄物（ＨＬＷ）の返還にかんがみて、ＨＬＷおよび使用済み燃料の地層処分を中心に行われている。

ＮＥＡの加盟諸国の地層処分計画は、概念調査、立地選定、サイト特性調査、地下研究所の開発、原位置実験、および処分場の開発など、様々な段階にある。地下研究所の開発は、安全性評価モデルや技法を実証するために地層処分システムを実現する上で重要なステップである。

ＮＥＡの廃棄物管理プログラムの優先順位は、加盟諸国の状況を反映しており、それがＨＬＷと使用済み燃料の地層処分である。ガラス固化技術がすでに開発されており、ＮＥＡ加盟諸国で４カ所のガラス固化施設が稼働している。ガラス固化ＨＬＷの安全仕様は、関係国家当局の承認を得ている。

ＮＥＡは、欧州、北米および極東の２７の加盟国で構成されており、加盟各国は政治・経済面ではほぼ同じ価値観を共有しているが、社会・文化状況はそれぞれ異なる。加盟諸国の原子力に対する態度も極めて多種多様である。このため、ＮＥＡが適切な会議（フォーラム）の場となって、新しい考えを生み出し、そこから複雑な問題を解決し、コンセンサスを醸成しようとしている。

Radioactive Waste Management from the OECD Perspective

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ABSTRACT

Various types of radioactive wastes are generated in nuclear facilities and suitable methods and strategies have been developed for the safe management of wastes: treatment and conditioning into stable forms, temporary storage awaiting disposal, controlled discharge into the environment and disposal in near surface or underground repositories. A number of repositories for low and medium level wastes are in operation and additional ones are planned in NEA Member countries.

Recent efforts have focused on geological disposal of high level waste and spent fuel, in view of the growing volume of spent fuel under temporary storage and the return of vitrified high level waste from the reprocessing of spent fuel.

Geological disposal programmes in NEA Member countries are at various stages: feasibility study, site selection, site characterisation, development of underground laboratory, in-situ experiments and development of repositories. Development of an underground laboratory is a key step in realising geological disposal systems in order to demonstrate safety assessment models and techniques.

The priority of the NEA waste management programme reflects the situation in Member countries and that is the disposal of high level waste and spent fuel in geological formations. The vitrification technology has been well developed and four vitrification plants are in operation in NEA Member countries. The safety specifications of vitrified high level waste have been approved by the national authorities concerned.

NEA is made up of 27 Member countries from Europe, North America and the Far East and they share similar political and economical values but their social and cultural conditions are different. Member countries' political attitudes toward nuclear energy are also quite diversified. This makes NEA a suitable forum to elaborate new ideas, to solve complex issues, and to develop consensus opinions.

Introduction

Various types of radioactive waste are generated in nuclear facilities and suitable methods have been developed for the safe management of wastes: treatment and conditioning into stable forms, temporary storage awaiting disposal, controlled discharge into the environment and disposal in near surface or underground repositories. A number of repositories for low and medium level wastes are in operation and additional ones are planned in NEA Member countries.

Recent efforts have been focused on geological disposal of high level waste and/or spent fuel, in view of the growing volume of spent fuel under temporary storage and the return of vitrified high level waste from reprocessing of spent fuel. Vitrified high level waste and spent fuel are safely stored in temporary storage facilities.

The priority of the NEA waste management programme reflects the situation in Member countries and that is the disposal of high level waste and spent fuel in geological formations. The vitrification technology has been well developed and several vitrification plants are in operation in NEA Member countries. The safety specifications of such high level waste have been approved by the national authorities concerned. Development of spent fuel encapsulation technology is underway.

NEA is made up of 27 Member countries from Europe, North America and the Far East and they share similar political and economical values but their social and cultural conditions are different. Member countries' political attitudes toward nuclear energy are also quite diversified. This makes NEA a suitable forum to evaluate new concepts, to seek solutions for complex issues, and to develop consensus opinions.

My presentation will focus on the disposal of high level waste and spent fuel in geological formations. In some countries the term "long-term storage in geological formation" has been used instead but the concepts are the same.

Overview of Geological Disposal Programmes

Geological disposal is not new. It was conceived and tried out at the onset of nuclear energy programmes. However, past programmes developed various technical shortcomings and led to undesirable levels of radioactive contamination in the environment. In NEA Member countries the past programmes were abandoned. The shortcomings came from lack of knowledge, technology and experience, and from bad planning.

The safety approach for geological disposal is very similar to the multi-barrier system for nuclear facilities: immobilisation of radioactive nuclides in glass matrices, confinement in canister, emplacement in repository with buffer materials and confinement in deep geological formation. In the safety evaluation scenario it is assumed that the multi-barrier system will degrade its integrity in the course of time and that radioactive nuclides will be transported into the geological media and eventually reach the human environment. Since their transport in the media will take a very long time, they will be allowed to decay to an unharmful level. This scenario is also the same for all nuclear facilities but the main difference is a passive nature of safety system and timescale. The scientific and technological challenge is, therefore, the capability to predict the long-term integrity of the multi-barrier system.

For the last 20 years, NEA Member countries have carried out extensive research and development programmes in this area. Geological disposal programmes in Member countries are at various stages: feasibility study, site selection, site characterisation, development of underground laboratory, in-situ experiments and development of repositories. Work in underground laboratories is a key step in the development of geological disposal systems in order to demonstrate safety assessment models and techniques. Several national programmes have been facing difficulties in the site selection stage.

The Yucca Mountain Project in the US is the most advanced: more than 90% of the main five mile underground loop for the Exploratory Studies Facility has been completed. Following the completion of a viability assessment of the site in 1998, a recommendation on the repository site will be submitted to the President in 2001 and if the site is suitable a license application will be submitted to the NRC in 2002 .

The Environmental and Ethical Basis of Geological Disposal

NEA has been a forum for sharing information and experience, strengthening scientific and technological confidence in safety assessment through co-ordination of national programmes, and sponsoring joint projects such as the Analogue Studies in the Alligator Rivers Region Project in Australia and the Stripa Project in Sweden. As a result of these efforts, NEA has contributed to developing technical and political positions. NEA has also, upon request, been conducting peer reviews of national programmes in the field of geological disposal.

Accumulation of scientific knowledge and experience and improvement in technology have strengthened the experts' confidence in the long-term safety of the geological disposal concept. This has resulted in the recent series of Collective Opinions. The first, in 1991, is entitled "Can Long-Term Safety be Evaluated?" and was developed in collaboration with the IAEA and the CEC. The second, in 1995, is entitled "The Environmental and Ethical Basis of Geological Disposal".

The main messages of the first Collective Opinion are that:

- safety assessment methods are available today to evaluate adequately the potential long-term radiological impacts of a carefully designed radioactive disposal system on humans and the environment, and

- appropriate use of safety assessment methods, coupled with sufficient information from proposed disposal sites, can provide the technical basis to decide whether specific disposal systems would offer to society a satisfactory level of safety for both current and future generations.

There is an ethical imperative to care about future generations and benefits from the earth's resources. Such concern for the protection of human health and the environment in a developing world has been illustrated by the concept of "sustainable development" put forward by the World Commission on the Environment, the Brundtland Commission, in 1987. This concept, which is principally an ethical one, was defined as "satisfying the need of the present, without compromising the ability of future generations to meet their own needs".

As part of its continuing review of the general situation in the field of radioactive waste management, and with particular reference to the extensive discussions at the NEA Workshop on Environmental and Ethical Aspects of Radioactive Disposal in 1994, the Radioactive Waste Management Committee reassessed the basis for geological disposal from an environmental and ethical perspective, at its special session in March 1995.

In particular the Committee focused its attention on fairness and equity considerations: between generations (inter-generational equity) and within contemporary generations (intra-generational equity).

The main messages of the second Collective Opinion are that:

- the geological disposal strategy can be designed and implemented in a manner that is sensitive and responsive to fundamental ethical and environmental considerations;

- it is justified, both environmentally and ethically, to continue development of geological repositories for those long-lived radioactive wastes which should be isolated from the biosphere for more than a few hundred years; and

- stepwise implementation of plans for geological disposal leaves open the possibility of adaptation, in the light of scientific progress and social acceptability, over several decades, and does not exclude the possibility that other options could be developed at a later stage.

Regulatory Aspects

National regulatory systems have been developed as geological disposal programmes progressed. In some Member countries, regulatory requirements have been reviewed to adjust to anticipated evolution.

Experts implementing national projects and regulators have occasionally exchanged views on how to apply regulation to future applications and to clarify scientific and technical details for regulatory requirements. Last January, NEA organised a Workshop on Regulating the Long-Term Safety of Radioactive Waste Disposal, in Spain, to contribute to a deeper understanding of regulatory approaches followed in NEA Member countries and of the differences which exist in national regulatory systems. Among suggestions made by the participants regarding further work were the drafting of rigorous but practicable regulations: the treatment of various uncertainties such as the living habits of populations in the far future and the need to make reasonable assumptions concerning these habits; and the difficulty of dealing with long-term risk issues in the context of legal and public perception considerations. The discussion highlighted that beyond the solid scientific basis required for safety assessment, the decision-making process must ultimately rely on expert judgment and reasonable assurance considerations, through an open and transparent process, allowing for public participation.

It is noteworthy that public participation in decision-making process such as public hearings or public inquiries has been applied.

On the international scene, various guidelines for management of radioactive waste were developed by the IAEA and they have, accordingly, been incorporated into national regulatory systems. A Radioactive Waste Management Convention, similar to the Nuclear Safety Convention, has been negotiated in the IAEA forum and it is expected to be opened for signature some time this year. It will provide an additional framework for the safe management of radioactive waste when it enters into force.

Financial Liability and Institutional Arrangements

Financial liability is another important aspect in the management of radioactive waste. The NEA carried out a study and published a report in 1996 entitled "Future Financial Liability of Nuclear Activities". Four approaches have been adopted in NEA Member countries: centralised fund and centralised responsibility, centralised fund and decentralised responsibility, guarantees and decentralised responsibilities, and decentralised responsibilities. The financial liability system will be refined in the course of the development of national repositories.

One of the advantages of geological disposal is less need for institutional control by future generations: monitoring, surveillance of site, etc. Institutional arrangements would depend on the national situation and be refined in the course of development. Once again, transparency of the decision-making process would guarantee the definition of reliable national arrangements.

Conclusions

National geological disposal programmes have been implemented and experts' confidence in the scientific and technological robustness of the safety assessment has been increased. This will be further demonstrated by underground laboratory tests being planned in several countries. It is hoped that the public will support the development of such laboratories and that the tests will be carried out in an atmosphere of mutual trust between those implementing the programmes and the public.

High level waste and spent fuel have long-term hazard potential and management of such waste requires particular consideration. These are not, however, unique for radioactive waste when the effects of industrial wastes containing hazardous elements are closely studied. I would like, therefore, to underline the need for a more rational attitude toward the management of radioactive waste. We may have developed a stereotype vision of the potential danger of nuclear energy based on past unfortunate events: nuclear bombs and accidents in nuclear facilities.

Since the quantity of waste to be disposed of is limited and resources are also limited, a single repository would be sufficient in most major nuclear power countries. International co-operation is therefoe imperative to share expertise and experience.

Modern society has been producing a variety of waste and some contains various chemical products with an extremely long life. Their risk potential has been recognised and various international control régimes have been discussed. A treaty to reduce the release into the environment of certain chemical compounds classed as persistent organic pollutants (POP) will be negotiated. Carbon fluoride compounds have been regulated by an international protocol. Green-house-effect gas may be subject to the control of an international convention. These developments reinforce my convictions.

Reference:

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ロシアにおける放射性廃棄物管理の現状の概観

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1996年までに、ロシア域内に蓄積した約40億キュリーの初期放射能をもった放射性廃棄物は6億5000万m^{3}を超えた。そのうちの90％は軍事生産によるものであり、その量と放射能の99％は、ロシア原子力省(Minatom・ミナトム)の関連施設から発生したものである。この数字には核実験および平和目的の核爆発(PNE)からの廃棄物は含まれていない。

原子力省およびその他の機関が貯蔵する使用済み燃料は約9,000トンに達し、その放射能は約46億5000万キュリーである。ある専門家によると、ロシア領土周辺の海域に放出された放射性廃棄物は、当初は230万キュリーであった。

きわめて多くの専門家の主張によると、ロシアの放射性廃棄物管理システムは、全体的に、国際原子力機関(IAEA)およびその他の国際基準からはいくぶんかけ離れている。ロシアの廃棄物については、国としての適切で総合的な貯蔵および埋設サイトのリストが完備されていない。

軍事用の放射性廃棄物は、下記の活動によって発生した。

－原子力省関連施設における核兵器の製造・蓄積
－海軍および国防産業省の原子力潜水艦等の原子力艦船の運転、修理およびその廃炉措置

原子力の平和利用による放射性廃棄物は下記の活動から発生する。

－原子力発電所(NPP)および研究炉、使用済み燃料の貯蔵およびその再生
－民間原子力船舶
－医療および工業用アイソトープの利用など

原子力の軍事利用と民間利用による放射性廃棄物(使用済み燃料)は3カ所のプラントで再処理される。

ウラル地方のオゼルスクのマヤク工場。ここは、23,000 km^{2}の面積に2000万キュリーの放射能を放出した1957年の大惨事で有名である。過去40年の歴史の中で、マヤク工場には10億 キュリーを超える放射性廃棄物が貯蔵されている。

セベルスクのシベリア化学コンビナート(旧トムスク)。260～450mの深地層に十分隔離された状態で50カ所に廃棄物が貯蔵されている。初期放射能の総量は11億キュリーである。

クラスノヤルスクのゼレズノゴロスク鉱山化学コンビナート。初期放射能 8 億キュリーが貯蔵されている。

これら 3 工場は、いずれも、最近、原子力の安全性とセキュリティーの改善を求める国際的活動の対象とされている。

200 万キュリーの放射能を持つ 200,000m³の放射性廃棄物は、原子力以外の利用分野から発生したものである。この廃棄物の管理責任は、国内に合計 16 の施設を持つラドンと呼ばれる州営会社にあり、中央の研究拠点としてボチバール記念無機材料研究所がある。このシステムは、1960 年代後半以来、成否はともかくとして機能し続けている。

放射性廃棄物の重要性に関して、安全性が十分確保されていない廃棄物が大量に存在するため、住民や環境に対する危険性に大きな関心が寄せられている。このため施設の再建や近代化が非常に重要であるにもかかわらず、十分な予算手当がされていない。

この問題を解決する試みが最近、放射性廃棄物管理に関する連邦委員会と地下埋設に関する省庁間委員会から提示されている。政府は、1996 年から 2005 年を対象とした連邦放射性廃棄物プログラムを採択した。このプログラムでは、実施するすべての活動の責任は原子力省が負うことになっている。廃棄物管理に関する法的な規定は、「放射性廃棄物管理に関する」法案によってカバーされる。同法案は、ロシア議会によって採択されるものと期待されている。

<u>**Overview of the current status of radioactive waste (RAW) management in Russia**</u>

summary by Andrei ZOBOV

Carnegie Moscow Center

By 1996 there were more than 650mln cubic meters of RAW with initial radioactivity of some 4bln Ku accumulated on Russian territory. 90% of that amount was from military production and 99% of both the amount and radioactivity was of the Russian Ministry for Atomic Energy (Minatom) origin. The figures do not include RAW from nuclear weapons testing and "PNE's"

There are also nearly 9000 tons of **<u>spent nuclear fuel</u>** in Minatom and other agencies storages with the radioactivity of about 4.65 bln Ku. According to some experts RAW released into the **<u>seas</u>** around the Russian territory was initially 2.3 mln Ku.

Quite a number of experts claim that the whole waste management system in Russia is somehow far from IAEA and other international standards. There is still no proper comprehensive national **<u>list of storage and burial sites</u>** for RAW in Russia.

The pile up of RAW in **<u>military</u>** sphere resulted from the following activities:

building-up nuclear weapons arsenal in the Minatom factories;

operations of and repairs on nuclear powered vessels of the Navy and the Ministry for Defence Industry and their decommissioning.

Radioactive wastes from **<u>peaceful</u>** uses of nuclear energy come from:

NPP and research reactors, storage of spent fuel and its regeneration;

civil nuclear powered ships;

use of isotops in medicine, industry, etc.

RAW from military and civil nuclear activities are **reprocessed** at three plants:

Mayak at Ozersk, the Urals known for the disaster in 1957 which released 20 mln Ku over the area of 23 000 sq.km. During 40 years of its history Mayak piled up more than 1bln Ku of RAW.

Siberian Chemical Combine at Seversk with 50 considerably well isolated storages in deep geological formations down to 260-450 meters deep. Total initial radioactivity - 1.1bln Ku.

Mining-Chemical Combine at Zheleznogorsk, Krasnoyarsky krai with 800 mln Ku of initial radioactivity. All three plants are objects of recent intensive international activity to improve nuclear safety and security.

200 000m^3 of wastes with 2 mln. Ku activity was of **non-nuclear application origin**. The management of that amount is the sole responsibility of a State Company called RODON having 16 plants all over the coutry and the central research base in the Bochvar Institute of Non-Organic Materials. The system is operative, successfully or not, since late 60-ties.

The importance of RAW problem: huge amount of not safely enough kept wastes creates great concern in view of the danger for the population and environment; badly needed reconstruction and modernization for which there are no sufficient funding in the budget.

An attempt to solve the problem is undertaken by recently created Federal Commission on Nuclear Wastes Management and Interagency Commission on Geologic Burial. The Government adopted a Federal Nuclear Wastes Program for 1996-2005 which named Minatom responsible for all operations within the Program. The legislation provisions on waste management are covered by the draft law "On Radioactive Wastes Management", which is expected to be adopted soon by the State Duma.

Overview of the current status of radioactive waste (RAW) management in Russia

Prepared by Andrei ZOBOV
Senior Advisor
Carnegie Moscow Center
for panel discussion on RAW management
at the 30th JAIF Annual Conference
Tokyo, April 11, 1997

I thank our distinguished hosts -- the Japan Atomic Industrial Forum for invitation to this important meeting. My presentation here is based on independent sources and expertise; facts, figures and conclusions given below do not necessarily coincide with official ones.

In preparing this presentation I relied substantially on the "Nuclear Encycopedia" recently published by Yaroshinskaya Foundation - an NGO in Moscow. I hear that this book is being translated from Russian into Japanese for publication in this country.

Like in other nuclear weapon states, RAW management in Russia from the very beginning was based on the requirements of nuclear weapons production. To win the arms race was the primary goal and the RAW problem was put aside until some time later in the future. In the case of Russia this postponement tactic is now proving itself to come to a dead-end: the country now has up to 1.7bln Cu of liquid medium and low level waste, plus 7.2bln Cu of high active waste and from 2.4 to 5bln Cu in spent fuel. And that is in addition to the radioactivity in contaminated environment. According to the available data the volume of RAW by 1996 was at the level of 650mln m^3. 90% of that amount is from military production and 99% of both the amount and radioactivity is of the Russian Ministry for Atomic Energy (Minatom) origin. The figures do not include RAW from nuclear weapons testing and the so-called "peaceful nuclear explosions". By the way, according with the existing national legislation spent fuel in Russia is considered RAW unless it is destined for reprocessing and reintroduction into the fuel cycle.

The problem of RAW in Russia as a continuing ecological threat is unfortunately rather far from its proper solution. Quite a number of experts claim that the whole waste management system in Russia falls behind the IAEA and other international standards. There is still no proper comprehensive national list of temporary storage and permanent burial sites for RAW in Russia. Huge amounts of loose wastes create great concern in view of the danger for the population and environment. Reconstruction and modernization of RAW facilities are badly needed for which there is no sufficient funding in the budget.

An attempt to solve the problem is undertaken by recently created Federal Commission on Nuclear Wastes Management and Interagency Commission on Geologic Burial. The Government adopted a Federal Nuclear Wastes Program for 1996-2005 which named Minatom responsible for all operations within the Program.

The biggest concentrations of RAW from military and civil nuclear activities are located at three sites:

1. Mayak at Ozersk (Chelyabinsk-65 and Chelyabinsk-40) in the Urals is well known for the disaster in 1957 which released 20 mln Cu over the area of 23 000 sq.km. During 40 years of its history Mayak piled up more than 1bln Cu of RAW.

2. Tomsk-7 the Siberian Chemical Combine at Seversk with 50 considerably well isolated storages in deep geological formations down to 260-450 meters deep. Total amount of liquid RAW pumped underground in Tomsk-7 is about 40mln m^3 with 1.1bln Cu of radioactivity.

3. Krasnoyarsk-26, the Mining-Chemical Combine at Zheleznogorsk with 800 mln Cu of radioactivity. All three plants produce RAW in radiochemical reprocessing operation. These plants are objects of recent intensive cooperative international activity to improve nuclear safety and security.

The Mayak RT-1 plant in Chelyabinsk is reprocessing spent fuel from some VVER, research and naval reactors. It has a capacity of 400 tons a year. Each ton makes some 600 000 Cu of RAW with the accumulation of 100mln Cu of RAW annually. An important practical problem with the RT-1 reprocessing plant is that the vetrification facility there had to stop functioning in the end of 1996. A new vetrification facility at Mayak will become operational only in 1999. So the situation with high active liquid wastes is becoming more and more serious every day.

The second reprocessing plant **RT-2** for other reactor types fuel with the capacity of 1500 tons a year was to be constructed at Krasnoyarsk-26. However due to lack of funding the construction work stopped and so far only one spent fuel storage was built there; it is operational now.

There are many conflicting views on **the future of the RT-2** reprocessing plant. NGO's, ecologists and GAN -the Russian equivalent to NRC- are against the construction, argue that there is no proof for its ecological, health and technological safety. The final verdict is expected from the Federal Ecological Expert Commission. The situation with cost-effectiveness for RT-2 operation is far from clear. If the plant were to take foreign spent fuel for reprocessing then it could theoretically make certain profit and be economically sound - and that is only in case of guaranteed shipments of foreign spent fuel for reprocessing. However the Russian Law on Environmental Protection prohibits import to Russia of RAW for temporary or permanent disposal. To overcome this situation President Yeltsin adopted a special Order of January 25, 1995 allowing for import of foreign spent fuel for reprocessing. The Government argued that 1)- the intention is to take not RAW but spent fuel and 2)- the spent fuel is from foreign NPP's built by the Soviet Union; the construction of these NPP and providing them with fresh fuel was conditioned on the return of the spent fuel to Soviet Union/Russia. The local authorities in Krasnoyarsk and the State Duma brought the case to the Constitutional Court of Russia. However the Court was unable to produce a proper judgement on the alleged ground that the Presidential Order in this particular case was not of "norm making character" and therefore not to be subjected to a Constitutional Court ruling. So the legal situation is still unclear.

The national patriots in Russia and especially in the State Duma are very loudly opposed to having any "garbage" nuclear material from abroad. However there is a growing understanding espacially in the academic circles in favour of not loosing possible benefits from a new industry - make use of the specific geographic, climatic, seismic and demographic situation of the huge Russian territory and earn money by reprocessing and storing radioactive materials from abroad.

In March 1995 The Russian Security Council Interagency Commission on Ecological Safety considered the item of ecology safety in the nuclear fuel cycle. It found that the scientifically proven ecologic and economic criteria and merits assessments of closed and open fuel cycles have not been properly developed in Russia. The Commission requested Minatom and other agencies to work out and submit to the Government such criteria and assessments for the purpose of formulating the concept of safe development of nuclear power in the country. This work has not been done yet.

The proper assessment of RAW situation much depends on which concept of the nuclear fuel cycle is accepted in the country- **the closed or open fuel cycle**. In practice the fuel cycle in Russia can not be considered as a completely closed one because, for instance, Pu from NPP spent fuel is kept in special storages at Mayak RT-1 plant and not yet returned back to the fuel cycle. Thus at the moment this Pu is practically a RAW. On the other hand the fuel cycle can not be quite open because there is no final stage of permanent disposal and both RAW and spent fuel are so far put into temporary storage. So both types of the cycle have important element of transitory nature.

Minatom has made its choice squarely in favor of the closed type of nuclear fuel cycle. To materialize this choice the Ministry has to take into account several criteria of RAW management.

First, the need to lower the **population and environmental risks**. If the closed cycle were to be proven to lead to higher risks, then this cycle is unacceptable irrespective of possible economic attractiveness and benefits. How to solve the problem of increased quantaties of RAW resulting from the closed cycle choice is not clear. Another problem which is still difficult to solve - insufficient storage space for midium and low active waste.

Cost-effectiveness. Of cource the closed cycle RAW reprocessing opportunities might attract much needed investments from foreign nuclear industries. But very much depends on concrete situation in the world markets. The official figures might show that total expenditures on RAW and spent fuel reprocessing in the closed cycle to be 10-15% lower than storage and permanent disposal expenditures in the open cycle. However there are some independent calculations showing that the closed cycle costs might be 10-30% higher than in the open cycle. To make the correct calculations in this regard very much will depend on whether Russia will succeed in making the storages less expensive and making its sales of uranium and enrichment-reprocessing services more attractive to foreign markets.

Conformity with the existing **legislation** provisions. The Government, if it wants the public opinion to accept the closed cycle, has to completely convince it of the benefits of accepting foreign spent fuel and RAW for reprocessing and storage, and to change the existing legislation accordingly.

Nuclear **non-proliferation** considerations relevant to each of the two types of the fuel cycle are well known and are still debated hotly not only in Russia.

There is quite a number of considerations unrelated to the type of fuel cycle which are to be taken very seriously

Russia is not yet guaranteed against the threat of a serious **political and social change** or an attempt of such change. Together with a fast growing interest from some **rogue states and non-government groups** in obtaining fissile materials it makes it absolutely imperative to provide reliable measures of RAW safety and security. International cooperation plays an extremely important role in this area.

In 1996 eight train loads of **RAW from the Navy** (six from the Northern Fleet and two from the Pacific) were transported from the submarines and local harbor storages to more permanent storage facilities - mainly in the Mayak. The plan now is to remove some ten train loads per year so that by the year 2000 all Navy spent fuel is removed

Use of isotops in medicine, industry, etc. and other uses of fissile materials outside of power production led to the accumulation of 200 000m^3 of wastes with 2 mln. Cu activity. The management of that amount is the sole responsibility of a State Company called RODON having 16 plants all over the country. Its central research base is the Bochvar Institute of Non-Organic Materials. The system is operative, successfully or not, since late 60-ties.

<u>**The National Legislation Relating to RAW in Russia**</u>. From the very beginning all nuclear activities in USSR/Russia were kept secret and nobody was speaking of any public laws in this area. Things began to change in real terms only in 1992 when the Parliament elaborated two nuclear related laws - "On Utilization of Atomic Energy" and "On National Policy in Radioactive Wastes Management". These Laws were adopted by the State Duma in 1994 but the President signed only "On Utilization of Atomic Energy" and vetoed the Wastes Law. The prevailing opinion among independent expert is that this was done under lobbying pressure of the military establishment and Minatom. These two organizations opposed the Wastes Law mainly because this Law did not permit disposal of medium and high active liquid RAW and also prohibited any disposal of any RAW onto the open ground or into rivers and lakes. The Law also contained the strict rule that high level RAW could only be buried in solid form and in explosion- and fire-proof state, into deep seismic-proof geological formations. These legislation provisions would drastically toughen the whole national practice of RAW utilization and management. This leads to the situation when Minatom might think to be much better off without the Wastes Law. The absence of this Law does not help elaboration of a national RAW management concept.

RAW and public information, transparency/openness. Despite recent visible successes in Russia in ecological information openness and legal protection measures in comparison with the Soviet period, some ugly Soviet-type problems continue. A latest example- the case of retired Northern Navy officer Alexander Nikitin who provided a Norwegian ecology group Bellona with certain ecological data relating to RAW situation in the Russian North. He is accused of betraying state military secrets. His case is still in court and very much is still unclear. Russian ecologists argue that the military must recognize that national security is not confined to defending against a potential external enemy, but comprises also a no less important ecological component and therefore publicity is not necessarily a betrayal.

Closeness of nuclear facilities and RAW to densly populated areas. The most striking example -- Kurchatov Institute with its 28 nuclear sites is only 15km away from the Kremlin in the center of Moscow. Another example -- Tomsk-7 Plant - the huge Siberian Chemical Combine with its official 1bln Cu of RAW is only 10km from Tomsk.

Another problem in RAW management - **depth of pumping for geological burial** is not deeper than 450m (in Tomsk-7), which according to many experts is not deep enough

International efforts for radioactive waste management and the Russian role. An internationally recognized consensus has developed namely that the prime responsibility for safe management of radioactive waste, including storage and final disposal, rests with national governments. The promotion of an effective safe wastes management culture in each country requires a supportive economic and legal environment and international transparency.

However in light of the consequences of a major nuclear disaster it is of the first importance to continue to enhance international collaborative efforts to promote safe waste management worldwide.

A promising endeavor in this area could very well be establishment of regional storages for RAW. Russia supports international efforts in this field. This now becomes an interesting topic during bilateral and multilateral discussions.

Significant efforts have been made in Russian Federation towards safer waste management independently and also in cooperation with multilateral and bilateral programs. This effort follows the guidelines of the Moscow Summit of the Eight Powers exactly a year ago on Nuclear Safety and Security. But of course further substantial efforts are still required

International Convention on the Safety of RAW Management. RAW management issues are increasingly important to the public perception of nuclear energy. Therefore the Convention on Nuclear Safety contains an affirmation of the need to develop a convention on the safety of RAW management. Work on elaboration of the Convention on the Safety of RAW Management started began in 1995 and is progressing. Russia actively supports this excersize in the understanding that this Convention will be useful to ensure that countries properly manage their waste to avoid unacceptable risks now or in the future to both the public and the environment.

Commitments on Ocean Dumping. In 1996 Russia finally joined the 1993 amendment to the London Convention to ban sea disposal of all RAW, including low-level.

In 1993 Russia discharged low level liquid wastes into the Sea of Japan. A joint Russian, Japanese and Korean study was conducted.

The IAEA has undertaken a 4 year International Arctic Seas Assessment Project to assess the health and environmental risks and to examine possible remedial actions. There are also joint Russian/Norwegian scientific cruises in the Kara Sea. As the Russian Federation does not currently have sufficient capacity to treat low level liquid waste from their

Nordic and Pacific nuclear fleets, Japan, the United States, the Nordic countries and the Republic of Korea are assisting Russia through bilateral and multilateral channels in construction of waste treatment facilities.

９７年原産年次大会／「エネルギーの廃棄物にいかに対処するか」

日本生協連
品川　尚志

１．日本生活協同組合連合会とは、全国の７００余りの生活協同組合が加入している連合会です。全国の生協を合計すると、組合員数１９４１万人、１年間の総事業高（殆どが小売事業としての販売高）は３兆４０００億円弱というのが今年３月末の実績数値です。これまで日本の生協は、特に「食生活の安全と安心」を中心の柱に活動と事業を進めてきました。
９０年代に入ってからは、それだけでなく福祉、健康、環境、平和といったより広いテーマを掲げて運動を進めています。

２．地球環境を考えるとき、これまでのような生産性最優先ではなく環境保全型の社会経済システムに転換していくことが、極めて重要です。このテーマに日本の生協として挑戦する上で、広範な市民自身のくらし方と生協自身の事業のあり方を、率先して環境保全型に切り替えていくことを重点にしています。
具体的には例えば牛乳パックの回収運動を進めています。９５年に生協で集めた量は６６６０トンで、これは全国で回収されている牛乳パックの３～４割にあたります。食品のトレイやペットボトルの回収も進めています。こうした活動を進めることによって、市民にとっては日頃のくらし方をリサイクル型に切り替えていくきっかけになり、商品流通のシステムの中にリサイクルのルートを組み込んでいく契機にもなっています。もちろん回収した資源を商品化し、それを利用するくらし方も広げているわけです。
しかし、そうした活動を市民の中に広げていくと、「生協は消費者にはリサイクルを言いながら、自分の店では裏に回ると毎日膨大なゴミを出しているではないか」という批判も広がっていくという関係になってきます。
そうした批判にきちんと応えられる流通事業体になっていくために、環境マネジメントシステムを導入し、いわば恥部を含めてその結果を毎年公表して理解を広げています。その外にも環境保全型の商品開発を進め、環境保全のための様々な市民活動に取り組んでいます。

３．このような活動を進めている生協の場から、核廃棄物を巡る問題について思うことは積極的な情報公開と市民参加ということです。
もんじゅや東海村の事件で、できるだけ公開の範囲を狭め、遅らせるとい

った対応が印象づけられています。情報公開についてのこうした対応や印象は、核廃棄物の安全性そのものの問題以上に、国民の不信を増幅させ、核の平和利用の道を自ら狭めているという現実を直視すべきでしょう。
原子力発電にこれだけ多くを依存している日本の現実にあって、核廃棄物問題が国民全体にとって避けて通れない問題であることを、後ろ暗さを秘めてではなく、もっとおおらかに率直に理解を求めることが必要です。個別の施設についても、地元住民やその推薦する専門家の、建設の計画から稼動後の定期的な検査までへの参加を可能な限り組み立てることです。
また生協では、長年にわたって核兵器を地球からなくす運動にも取り組んでいます。オール地球で核の軍事利用の道を完全に閉ざすことは、平和利用への国民の理解を広げる大きな要素になると思います。原子力産業の立場からも、そうした面で市民と共同することで理解を深め合うことなどもお考えいただいたらいかがかと思うものです。

以上

私のえがく「アジアトム」

日本原子力産業会議副会長
村田　浩

最近の数年、停滞する西欧やロシアの経済情勢の中で中国をはじめ東南アジアをふくむアジア地域の著しい経済発展ぶりに注目が集まっている。特に経済成長の高い国々では年率１０％を越え、アジア地域全体の平均でも率６－７％をこえている。このような急速な経済発展と増大する人口増等のため、アジア地域のエネルギー消費量増加も著しい。特に地域社会の近代化にともない電力需要増は極めて大きく、国によっては年率１５％にも達する勢いである。

こうした高い経済成長、人口増に対処するために、２１世紀にはますます大きく中東地域の石油に依存せざるをえず、再び重大な石油危機、そして石油争奪戦が展開されるおそれがあるであろう。

このような見通しに対しては、いまから各国が協力してエネルギー供給力の増加、特に電力資源の急速な開発が不可欠であることは、多くの識者の等しく指摘するところである。さらに炭化水素資源の利用増大にともなう環境汚染を考えれば、行き着く先は原子力発電計画の強力な推進ということにならざるを得ないであろう。

しかしその一方において、高度の技術力を必要とする原子力発電のアジア地域における拡大には、安全性確保等の点で危惧の声も聞かれる。しかしエネルギーの問題を放置するわけにいかないのは自明であるとすれば、いかにしてアジア地域の原子力安全を確立できるかが、問題の解決につながる。

１９９５年末現在のアジア地域諸国の原子力発電開発状況を見ると、運転中６９基、建設中１０基、計画中２０基で合計９９基となっている。これはほとんど現在の米国の合計１１０基に匹敵し、２１世紀半ばまでにほぼ１５０基にのぼるのは必然とみられている、このような見通しから先進工業国側はそれぞれ原子力発電所の売り込みに力をいれており、その成果も上がりつつあるようである。

しかし原子力発電の急速な地域的な発展に国際的に対処するためには、数量的に増加する原子力施設に対する安全保障措置と安全性確立が絶対の要件であり、また原子力発電規模が増えるにともない、これを支える核燃料サイクルの確立が大きな問題となる。

現在のところ我が国と中国を除いては核燃料サイクル政策は未確立であるが、今のうちから原

子力発電発展の重要な課題である安全保障制度と核燃料サイクル確立とをアジア地域の新たな制度として発展させるべく、一つ重要な地域システム、すなわち「アジアトム」の設立を構想し、その実現に協力していくべき時ではないかと考える。

「アジアトム」という名称からは、直ちに「ユーラトム」が頭に浮かぶが開発の歴史、地域の経済、社会構造、文化等の違いから見て、「ユーラトム」のアジア版というわけにはいかないであろう。

私のえがく「アジアトム」では一方で国際原子力機関（ＩＡＥＡ）の保障措置を補完する機能をもち、併せて地域内諸国に将来必要となる核燃料サイクル施設を各国が分担することにより、地域の協力体制を一段と強化し、平和利用に徹する原子力計画の健全かつ能率的な地域協力を確立させることにあるとおもう。

ASIATOM—A Personal View

Hiroshi Murata
Vice Chairman
Japan Atomic Industrial Forum, Inc.

In recent years, attention has been paid to remarkable economic growth in the Asian region, including China and the Southeast Asia, amid the stagnant economic conditions in the West and Russia. In some countries with high economic growth, the growth rate has exceeded 10 percent a year, and even the average annual growth rate is over 6 - 7 percent in the whole Asian region. Because of such rapidly growing economy and increasing population, energy consumption has also remarkably increased in the region. Especially, with modernization of local communities, electricity demand is sharply growing, at a rate of as high as nearly 15 percent a year in some countries.

To cope with such high economic growth and population increase, the nations are obliged to be more dependent on oil produced in the Middle East region. This situation may give rise to another serious oil crisis and lead to a fierce competition for oil. Regarding such prospects, many insightful people have pointed out that it is essential for the world nations to work together now to increase energy supply, especially to develop power resources quickly. Considering the environmental pollution caused by the increased use of hydrocarbon resources, we cannot but conclude that the strong promotion of nuclear power generation is the only way to go.

On the other hand, some people show concern about the assurance of safety, in the face of the Asian region's rapid growth of nuclear power generation, which requires sophisticated technology. It is evident, however, that we cannot leave the energy shortage as it is. The important task therefore is to establish nuclear safety in the Asian region. This will lead to the solution of the problem.

As for the nuclear development situation in the Asian region as of the end of 1995, 69 units were in operation, 10 units under construction, and 20 units at the planning stages. This means the region will have a total of 99 units. This number is almost equivalent to those units owned by the United States—110 units. It is expected that the Asian countries will have nearly 150 units by the middle of the 21st century. From such a perspective, the industrialized nations are making efforts to sell nuclear power plants to the nations in the region, and are achieving considerable results.

However, to internationally cope with the rapid nuclear power development in the region, it is absolutely necessary to ensure safety and to provide the safeguards for the nuclear materials which are growing in quantity. Furthermore, with the increase in nuclear power generation capacity, it is becoming increasingly important for the nations to close the nuclear fuel cycle supporting it.

At present, only Japan and China have succeeded in closing the nuclear fuel cycle in the region. It seems to me that it is time to plan the establishment of an important regional system, namely, "ASIATOM," and to work together to realize this new system, under which we should promote the establishment of the safeguards system and the closing of nuclear fuel cycle.

The name "ASIATOM" will immediately remind us of "EURATOM," but in consideration of the differences in the history of nuclear development, regional economy, social structure, and cultures, it will not be appropriate to call this system an Asian version of "EURATOM." "ASIATOM" which I picture would have functions complementing the safeguards provided by the International Atomic Energy Agency (IAEA). At the same time, the member nations would share the nuclear fuel cycle facilities which will be needed in the region. By doing so, the nations could further strengthen the regional cooperative system to realize a sound and efficient cooperation in developing nuclear power exclusively for peaceful uses.

私がえがく「アジアトム」

日本原子力産業会議副会長

村　田　　浩

I

チェルノブイリ原子力発電所の事故が発生してから１０年が経過した。この間の世界の原子力発電状況をみると、西欧諸国の原子力先進国での新規建設が、ほぼ全面的に停滞するなかで、この数年のアジア地域における原子力発電計画の進展が目立つ。この地域にはわが国をはじめ韓国のように既に十数基〜数十基の原子力発電所の建設運転を着実に発展させてきた国もあるが、最近数年の状況をみると、世界の中で経済成長の著しい中国をはじめ、アジア諸国の原子力発電計画への参入とその増設がめだち、先進工業諸国から輸出市場としても大きな関心が寄せられている。

「アジアの基礎指針（Ⅰ）」によれば、１９８５年〜９４年の１０年間のＧＮＰ成長率は、日本は３．２％に対し、中国７．８％、インドネシア６．０％、韓国７．８％、マレーシア５．６％、タイ８．６％、フィリピン１．７％である。また、人口一人当たりのエネルギー消費量（ＫＯＥ）は、日本の３，８２５に対し中国６４７、インドネシア３９３、韓国３，０００、マレーシア１，７１１、タイ７７０、フィリピン３６４と、日本、韓国、マレーシア以外はすべて１，０００以下である。このような情勢の中で、わが国はどのような政策の下にアジア地域の発展に有効な協力を行うべきであろうか。

そこで２１世紀には逼迫が予想される化石燃料への有力な代替エネルギーとして、アジア地域においても原子力発電が推進されるのは必然の成りゆきではないだろうか。しかしアジア地域諸国の大半が、なお開発途上に属することから、原子力発電計画の発展に危惧を抱く向きもあるようである。それは原子力発電計画の推進に不可欠な要素である「安全保障」（核兵器への転出防止）と「安全性確保」の面で、開発途上国側に充分な人材、資産、技術が欠除しているのではないかという点であろう。したがって、アジア地域での今後の原子力発電計画の推進に当たっては、わが国を含め先進工業諸国がこれらの要素を充分考慮に入れた技術協力、経済支援策を確実に推進

しなければならない。

ここで、アジア地域諸国の経済情勢を見る一助として、少し古いデータであるが、１９９４年世界年鑑（Ｗｏｒｌｄ　Ａｌｍａｎａｃ）によるアジアの基礎指標（Ⅱ）を示したい。この表によれば、日本と韓国を別とすれば多くのアジア地域諸国は、なお発展途上に入ることは明らかである。これらの基礎指標はおおかたの人々の予想、予測と大きな違いはないかと思われるが、ひとつ特に指摘しておきたいのは「識字率」である。韓国の識字率がわが国と並んで高いのは当然としても、フィリピン、インドネシア、タイ、マレーシアも８０％以上を示しているのは、教育の普及と無関係ではないと思われる。

さて、これらアジア地域諸国に対する技術協力、経済支援等についての具体策となると、いまのところ個別的な協力計画或は発電所建設計画は見られても、将来を見据えたアジア地域全体を包含する組織的な協力支援体制はできていないし、各国バラバラの援助活動（もっぱら商業的な）に委され、しかも発電所建設だけが対象とされ、長期にわたりこれを活動させるための不可欠な部門、すなわち核燃料サイクル関係の支援協力構想が見られない。いうまでもなく原子力発電が地域或いは個々の国の電力源として長期にわたり有効に寄与するためには、原子力発電を支えるフロント・エンド並びにバックエンドの整備がなされねばならない。

わが国においては　原子力発電の規模が大きく、国内市場のみを対象とする核燃料サイクル事業が成立しうるが、アジア地域の多くの国では一部を除き、自国内に核燃料サイクル施設のすべてを整備することは極めて困難であり、安全保障並び安全性確保の上からも問題を複雑化するのを免れない。ここにおいて域内の共同的核燃料サイクル事業を含む協力計画を、現時点において構想し最も有効な原子力発電システムを考えておく必要があると考える。このような地域的協力構想をここで一応「アジアトム」と呼ぶこととし、私自身の考えるアジアトム構想の概略を披露し、関係者の議論の材料としたい。

なお「アジアトム」という名称は、直ちに現在欧州に存在する「ユーラトム」を連想させるが、その内容はかなり違っており、単にユーラトムのアジア版といった解釈

では将来にわたり有効なシステムとして発展し機能するのは困難であろう。そのことは「ユーラトム」成立の歴史と機能と、ここで言う「アジアトム」とでは種々の点で大きな違いがあるからである。また最近、「アジアトム」に対し米国、カナダ、場合によっては極東ロシアを含めた「パシフィカトム」と言う意見も出ているが、この両者を混用するのは焦点をぼかし、理解の一致にも多大の時間を要すると考えられるので、ここではアジア地域を対象とする「アジアトム」構想として、自分の考えるところを述べるにとどめたい。

II

最初に私の考える「アジアトム」構想の要点を示しておきたい。まず「アジアトム」とは二つの機能を併せもった地域メカニズムと規定する。第一の機能は「安全性」(安全性については既に一部WANOが機能しているが）並びに「安全保障」のより効果的な確保であり、第二の機能は「核燃料サイクル」事業の地域的整備である。

第一の点については、これまでも国際原子力機関（ＩＡＥＡ）の保障措置（ＳＧ)システムでカバーされており、その機能は現在策定中の「９３＋２」計画の具体化により、これまでより一段と整備されることとなっている。

しかし、ここでの問題は整備されるためには、ＩＡＥＡの予算とＳＧ要員の大幅な強化を必要とすることである。そこで「ユーラトム」の保障措置制度をみると、ユーラトム諸国の原子力施設はまずユーラトム組織自体のＳＧ活動でカバーされ、次いでこれをＩＡＥＡが検認（ｖｅｒｉｆｙ）する形で行われている。これによりＳＧそのものは二重にチェックされ、ＩＡＥＡのＳＧ業務負担も或る程度軽減される。現在、ユーラトム諸国に存在する原子力発電所は計１４５基、１億２，５００万ｋＷであり、研究施設等をふくむ原子力施設の合計は約４４０箇所に及んでいる。一方アジア地域においては、現在のところ原子力発電所は計８２基、６，１７２万ｋＷ、その他の原子力施設をふくめると合計約１７０箇所であるが、２１世紀にかけ次々と原子力発電所等が建設、運転に入ることが予想され、一応の推定によれば２０２０年頃には合計約３００箇所、さらに２０５０年頃までには現在のユーラトム地域の施設数を上廻ることが予想される。これらには当然、核燃料を供給する施設（フロントエンド）とリサイクル施設（バックエンド）が加わる。したがって、原子力発電所の運転管理と廃棄物管理処分が大きな負担となるおそれがある。

また原子力発電所と異なり、核燃料サイクル施設を発電国がそれぞれ別箇に整備することはきわめて不経済であり、かつまた安全保障上の問題も増加する。したがって、いまのうちからアジア地域の将来を見越した核燃料サイクル施設の地域内共同利用を図ることが、経済的にも、核不核散政策上も望ましく、また既に問題化しつつある放射性廃棄物の処理処分対策上も有益であろう。

Ⅲ

ここで私の考えるアジアトム構想を例示的に述べるとすれば、まず核燃料サイクル施設については、ウラン濃縮工場をオーストラリアに設置する。ここでは主として同国で産出するウランを原料として豊富な水力を利用する。濃縮技術（例えば遠心分離法）については、日本等の経験を生かして協力援助する。次に主として軽水炉になると思われるが、その燃料体（要素）の製造については、既に国内に燃料製造施設を持つ韓国の協力に依存する。或いは今後の見通しとして日本や韓国など海外からの技術導入により、インドネシアに施設を設けるのも一策であろう。

以上はいわゆるフロントエンドの施設であるが、問題はバックストリームの方であろう。現在使用済燃料の再処理技術を有するのは日本と中国であるが、わが国が他国の使用済燃料の再処理を引き受けることは、種々の面で大きな困難が予想されるので、ここのところは中国にアジア地域共同の再処理施設をお願いする。この方針が実現可能であるならば、再処理事業に伴う使用済燃料の長期貯蔵並びに高レベル廃棄物の処分を併せて中国に担当してもらってはどうか。もちろんこのような提案を中国が如何なる条件で受け入れるかどうか。 現時点では全く不明であるが、前提としてアジア地域全体の協力体制強化のために中国がこのような案件に協力的であること、併せて資源的技術的に有力な地位にある日本及び米国の理解が不可欠であろうと考えられる。

次に安全保障体制の強化についてはどうであろうか。アジアトム構想が実現すれば、第一次の保障措置はアジアトムＳＧ要員が、原子力発電施設並びに核燃料サイクル施設の査察を実施し、これをＩＡＥＡのＳＧ要員がチェックする。アジアトムＳＧの本部は日本（例えば東京）に置き、所要経費の大半は日本政府が負担する。もちろんＳＧ要員はアジアトム加盟各国から専門家を出してもらう。このような安全保障体制が実現できれば、域内諸国の原子力活動の交流が一層進展し、前述の核燃料サイクルの地域構想の実現についても有効に働くのではないだろうか。

以上に述べたことは、２１世紀のアジア地域原子力活動の発展をにらんでの一つの地域協力の考え方であり、その実現はもとより容易なことではない。アジアトムの実

現をどのような体制で取り組むか。莫大な所要資金をどのようにまかなうか。必要な人材が十分に得られるか等々困難な問題は目白押しにある。その一つ一つを解決していくには、大変な国際的努力が必要であり時間もかかる。しかしアジア地域の原子力開発が２１世紀に大きく発展することを考えれば、困難な問題であっても今から関係者が機会あるごとに取り上げ議論し、発展への道を探っていくべきではないかと考えている。

ここで、いわゆる「アジアトム」についての優れた研究について触れておきたい。それは、東海大学の金子熊夫教授を中心とする「アジアトム」構想である。金子教授は独自のグループ活動により数年前から「アジアトム」構想について提案し、アジア諸国の関係者とも意見を交すとともに、「アジアトム憲章」の草案を起草し、構想の推進に努力を傾注しておられる。私もそのグループ会合に出席したこともあり、大変関心を寄せているが、本日の講演は直接にそれとは関連しておらず、私自身の責任にもとづくものである。一方が政治面、法制面からのアプローチとすれば、他方は技術面、経済面からのアプローチとみることができるかもしれない。いずれにしても「アジアトム」問題が今後さらに各方面において一層討議されることを望みたい。

以上

私がえがく「アジアトム」

附表・附図

（以上）

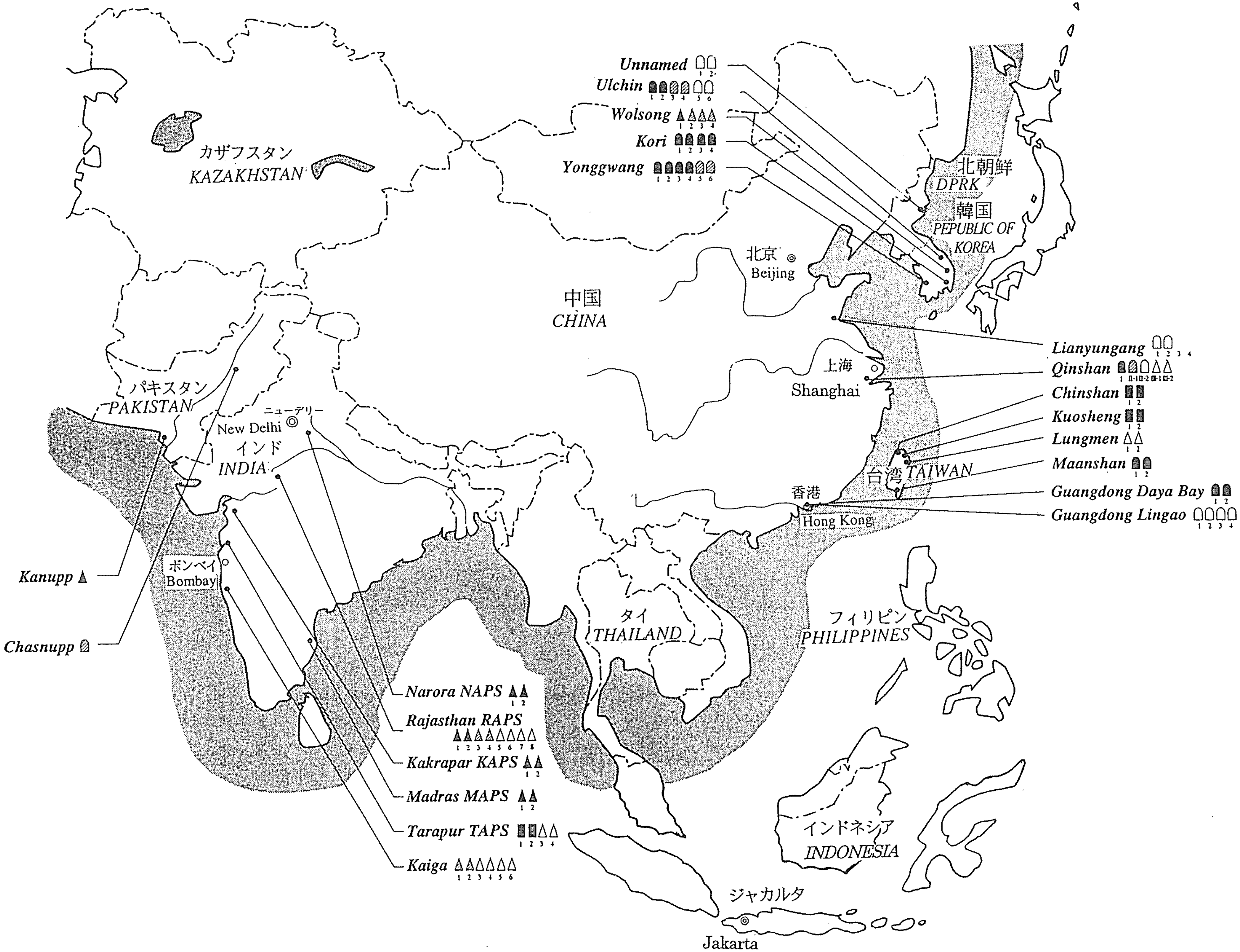
第１表　世界の原子力発電設備容量

―1996年12月31日現在―

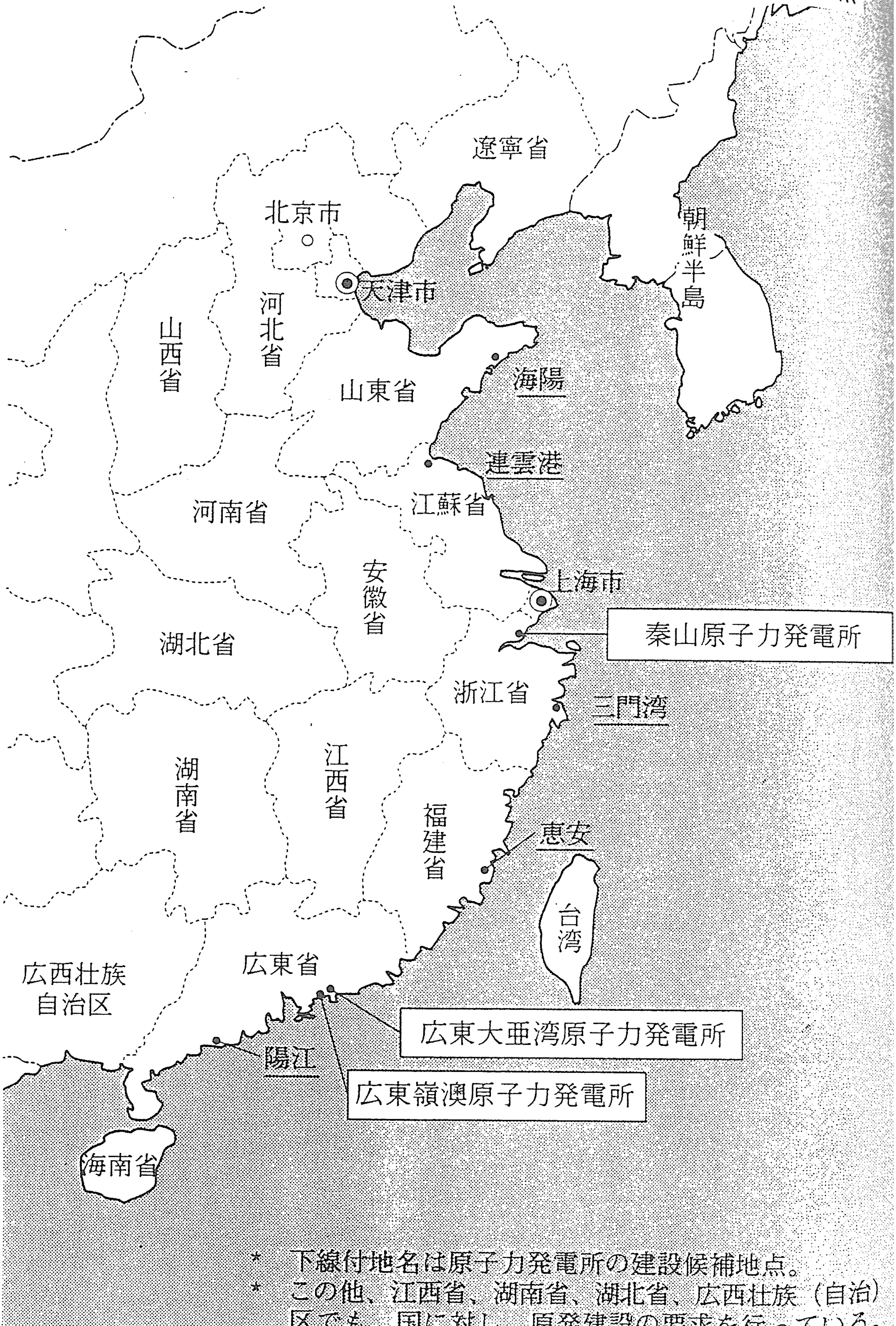
（万kW，グロス電気出力）

国・地域		運転中		建設中		計画中		合計	
		出力	基数	出力	基数	出力	基数	出力	基数
1	米国	10,538.1	109					10,538.1	109
2	フランス	6,103.3	56	606.0	4	303.0	2	7,012.3	62
3	日本	4,271.2	51	364.1	4	192.5	2	4,827.8	57
4	ドイツ	2,345.1	20					2,345.1	20
5	ロシア	2,125.6	26	740.0	8	901.6	15	3,767.2	49
6	カナダ	1,579.5	21					1,579.5	21
7	英国	1,417.3	35					1,417.3	35
8	ウクライナ	1,388.0	15	300.0	3	200.0	2	1,888.0	20
9	スウェーデン	1,043.7	12					1,043.7	12
10	韓国	961.6	11	610.0	7	200.0	2	1,771.6	20
11	スペイン	750.0	9					750.0	9
12	ベルギー	599.5	7					599.5	7
13	台湾	514.4	6			270.0	2	784.4	8
14	ブルガリア	376.0	6					376.0	6
15	スイス	320.5	5					320.5	5
16	リトアニア	300.0	2					300.0	2
17	フィンランド	240.0	4					240.0	4
18	中国	226.8	3	60.0	1	1,000.0	11	1,286.8	15
19	南アフリカ	193.0	2					193.0	2
20	インド	184.0	10	88.0	4	588.0	12	860.0	26
21	ハンガリー	184.0	4					184.0	4
22	チェコ	176.0	4	194.4	2			370.4	6
23	スロバキア	174.0	4	88.0	2	88.0	2	350.0	8
24	メキシコ	130.8	2					130.8	2
25	アルゼンチン	100.5	2	74.5	1			175.0	3
26	ルーマニア	71.0	1	264.0	4			335.0	5
27	スロベニア	66.4	1					66.4	1
28	ブラジル	65.7	1	130.9	1	130.9	1	327.5	3
29	オランダ	53.9	2					53.9	2
30	アルメニア	40.8	1					40.8	1
31	カザフスタン	15.0	1					15.0	1
32	パキスタン	13.7	1	32.5	1			46.2	2
33	イラン			229.3	2	152.0	4	381.3	6
34	キューバ			88.0	2			88.0	2
35	エジプト					187.2	2	187.2	2
36	イスラエル					66.4	1	66.4	1
37	トルコ					－	－	－	－
38	インドネシア					－	－	－	－
合計		36,569.4	434	3,869.7	46	4,279.6	58	44,718.7	538

第２図　アジアの原子力発電施設（日本を除く）



第１図　中国における原子力発電所立地地点と主な候補地点



＊　下線付地名は原子力発電所の建設候補地点。
＊　この他、江西省、湖南省、湖北省、広西壮族（自治）区でも、国に対し、原発建設の要求を行っている。

第2表　中国の原子力発電開発の現状

1．原子力発電開発計画

1996年12月末現在

状況	基数	名　称	炉型	万kW	着工・予定	運開・予定	主契約(予定)者
運転中	3基	広東省大亜湾1	PWR	98．4	1987年8月	1994年2月	フラマトム・GECアルストム
		広東省大亜湾2	PWR	98．4	1988年4月	1994年5月	同上
		秦山Ⅰ期1	PWR	30.0	1985年3月	1994年4月	中国核工業総公司
			小計	226.8			
建設中	1基	秦山Ⅱ期1	PWR	60.0	1996年6月	2002年6月	中国核工業総公司
			小計	60.0			
計画中	11基	秦山Ⅱ期2	PWR	60.0	1997年4月	2003年6月	中国核工業総公司
		秦山Ⅲ期1	CANDU	70.0	(近く着工予定)	2003年	カナダ原子力公社
		秦山Ⅲ期2	CANDU	70.0			同上
		広東省大亜湾嶺澳1	PWR	100.0	1997年5月	2003年	フラマトム・GECアルストム
		広東省大亜湾嶺澳2	PWR	100.0			同上
		江蘇省連雲港1	PWR	100.0	1998年	2004年	ロシア原子力省
		江蘇省連雲港2	PWR	100.0			同上
		＊上記7基までが第9次5カ年計画で承認済み					
		広東省大亜湾嶺澳3	PWR	100.0			未定
		広東省大亜湾嶺澳4	PWR	100.0			未定
		江蘇省連雲港3	未定	100.0			未定
		江蘇省連雲港4	未定	100.0			未定
			小計	1,000.0			

2．発電電力量内訳

１９９６年末現在

電源	発電量（ｋＷｈ）	割合（％）
火力	８，７２０億	８１．５
水力	１，８４０億	１７．２
原子力	１４０億	１．３
合計	１兆７００億	１００．０

＊総発電設備容量：２億３，０００万ｋＷ

3．発電規模予測

（ｋＷ）

年	原子力発電設備	総発電設備
２０００	２７５万	２．９億
２０１０	２，０００万	５．９億
２０２０	４，０００～６，０００万	８．０億

出典:中国核工業総公司　陳肇博　副総経理論文
於　第8回アジア地域原子力協力国際会議

第３表　世界のエネルギー資源可採確認埋蔵量

	可採確認埋蔵量	可採年数
石　油	９，９９１億バーレル	４６年
石　炭	１兆３９２億トン	２１９年
天然ガス	１４２兆立方メートル	６５年
ウラン	２０８万トン	４３年

（平成６年度原子力白書）

第４表　日本の食糧、エネルギー資源の海外依存度

１．日本の統計／１９９６　（総理府統計局編より）

（１９９４年度）

食糧自給率		海外依存度
米	７５％	２５％
小麦	１０％	９０％
大豆	２％	９８％
野菜	８９％	１１％
肉類	６４％	３６％
魚介類	７６％	２４％

２．総合エネルギー統計（資源エネルギー庁長官官房企画調査課編）

総合エネルギー需給バランス（１９９５年度）

	石炭(10^3t)	石油(10^3kl)	ＬＮＧ(10^3t)	原子力発電(10^6kWh)
国内エネルギー生産	6,952	862	-	269,127
輸入	119,771	267,916	42,481	-
一次エネルギー総供給	126,723	268,778	42,481	269,127
輸入依存度（％）	94.5	99.7	100	0

第５表　中国の中、長期経済とエネルギー資源需要の予測

	1980年	1985年	1990年	2000年	2030年	
ＧＮＰ（億米ﾄﾞﾙ）	2736	4597	6600	12030	51990	(20倍)
ｴﾈﾙｷﾞｰ需要　（標準炭換算億t）	6.02	8.41	9.91	14.1	34.5	(6倍)
電力需要　（万kWh）	300.6	407.3	550	1200	5186	(15倍)
ｴﾈﾙｷﾞｰ消費量 (1万米ﾄﾞﾙ当たり1t標準炭換算)	22.0	18.3	15.0	11.8	6.6	(1/3)
一人当たり　(米ﾄﾞﾙ ＧＮＰ　/人/年	277	439	593	962	3710	(15倍)
一人当たり年間（1t標準炭換算 ｴﾈﾙｷﾞｰ消費量　/人年）	0.61	0.8	0.89	1.13	2.46	(4倍)
一人当たり年間電力 消費量　(kWh/人年)	304	389	494	960	3700	(12倍)

注１．計算値は1980年の価格に換算したもの。
　２．１ＵＳ＄＝１．５５人民元（1980年）

第６表　中国における電力需要　（単位：兆ｋＷｈ）

	2000年	2015年	2030年	2050年
高　位	1.47	4.06	9.32	22.48
中　位	1.28	3.29	6.61	13.40
低　位	1.11	2.48	4.65	8.65

第７表　予想される中国の原子力発電開発計画　（単位：万ｋＷｅ）

	2000年	2005年	2010年	2015年	2020年	2030年	2050年
第１計画	350	1000	2000	3800	6400	13500	30000
第２計画	350	1900	2500	5000	8400	17000	35000

第８表　韓国のエネルギーおよび原子力発電開発の見通し

１．経済およびエネルギー事情

ＧＮＰの伸び	８．２％	（１９９４年）
	９．０％	（１９９５年）
輸入エネルギー依存度	９６．４％	（１９９４年）
	９６．９％	（１９９５年）

２．原子力発電開発計画

運転中	１１基	９６１万６０００ｋＷ
建設中	７基	６１０万ｋＷ
計画中	２基	２００万ｋＷ
合計	２０基	１７７１万６０００ｋＷ

＊１９９５年に改訂された長期電力需給計画によると、
さらに８基の建設に着手し２０１０年時点で
合計２７基を運転させる予定。
（古里１号機は２００９年に廃炉予定）

３．２０１０年における電源別設備容量

	設備容量（万ｋＷ）	比率（％）	発電シェア（％）
原子力	２，５３２．９	３３．１	４５．５
石炭	２，１７０．０	２７．３	３５．８
天然ガス	２，２０１．４	２７．７	１４．０
水力	５９８．０	７．５	１．４
石油	３５３．０	４．４	３．４

第9表　台湾の原子力発電開発状況

	原子力発電所	電気出力	炉型式
運転中	金山　1号	60万kW	BWR
	金山　2号	60万kW	BWR
	国聖　1号	98万kW	BWR
	国聖　2号	98万kW	BWR
	馬鞍山1号	95万kW	PWR
	馬鞍山2号	95万kW	PWR
計画中	龍門　1号	130万kW	ABWR
	龍門　2号	130万kW	ABWR

第10表　台湾の電源構成（予測）

発電設備容量

	原子力	石油火力	石炭火力	水力	LNG火力
1994年	24.5%	25.0%	28.1%	17.4%	5.0%
2001年	22.2%	13.9%	24.9%	14.2%	24.8%

第１１表　インドネシアの一次エネルギー供給割合（%）

一次エネルギー別	１９９０年	２０００年	２０１０年	２０１９年
石油	６０．２１	６０．７９	５１．１４	３４．３４
ガス	３２．５２	１８．６０	７．０１	３．４１
石炭	５．７２	１８．２１	３５．５５	５４．２９
原子力発電	０	０	３．９２	６．１８
水力・地熱等	１．５５	２．４０	２．３８	１．７９

（環太平洋原子力会議資料）

第１２表　インドネシアの原子力発電開発計画（９５年のＦ／Ｓ結果）

２００４年　　１号機　　６０万～９０万ｋＷ

２０１５年まで　合計１２基　　合計７００万ｋＷ以上

第１３表　タイの原子力発電開発計画（目標）

２００６年　　１号機　　１００万ｋＷ

２号機　　１００万ｋＷ

以下毎年１基（１００万ｋＷ級）を増設

第１４表　アジアの基礎指標（Ｉ）

			ﾊﾞﾝｸﾞﾗﾃﾞｨｼｭ	中国	インド	ｲﾝﾄﾞﾈｼｱ	韓国	マレーシア	ﾊﾟｷｽﾀﾝ	ﾌｨﾘﾋﾟﾝ	スリランカ	タイ	ベトナム	台湾	（日本）
人口（1994）（百万人）			117.9	1,190.9	913.6	190.4	44.5	19.7	126.3	67.0	17.9	58.0	72.0	21.1	125.0
面積 1000ｋ㎡			144	9,561	3,288	1,905	99	330	796	300	66	513	330	36	378
人工密度（1994）人／ｋｍ			819	125	278	100	449	60	159	223	271	113	218	586	331
年平均人口	1980-90		2.4	1.5	2.1	1.8	1.2	2.6	3.1	2.4	1.4	1.8	2.1		0.6
増加率(%)	1990-94		1.7	1.2	1.8	1.6	0.9	2.4	2.9	2.2	1.3	1.0	2.1	1.5	0.3
一人当たりＧＮＰ(1994) ﾄﾞﾙ			220	530	320	880	8,260	3,480	430	950	640	2,410	200	11,579	37,930
ＧＮＰ成長率(%) 1985-9			2.0	7.8	2.9	6.0	7.8	5.6	1.3	1.7	2.9	8.6			3.2
GNP配分 GNP top 20% / GNP bottom 20%			4.03	7.08	5.01	4.68		11.67	4.73	7.35	4.42	9.41	5.64		4.31
出生時平均余命 1994			57	69	62	63	71	71	60	65	72	69	68		79
産業構造	農業	1980	50	30	38	24	15	22	30	25	28	23			4
		1994	30	21	30	17	7	14	25	22	24	10	28	4	2
	工業	1980	16	49	26	42	40	38	25	39	30	29			42
		1994	18	47	28	41	43	43	25	33	25	39	30	37	40
ＧＤＰ	うち製造業	1980	11	41	18	13	29	21	16	26	18	22			29
		1994	10	37	18	24	29	32	18	23	16	29	22	29	27
(%)	ｻｰﾋﾞｽ業	1980	34	21	36	34	45	40	46	36	43	48			54
		1994	52	32	42	42	50	42	50	45	51	50	43	59	58
一人当たりｴﾈﾙｷﾞｰ		1980	32	421	137	169	1,087	692	142	277	96	259	75		2,972
消費ＫＯＥ		1994	65	647	243	393	3,000	1,711	255	364	111	770	105		3,825

出典：世界銀行　世界開発報告1996、台湾は台湾総覧1996

第１５表　アジアの基礎指標（Ⅱ）

	バングラデシュ	中　国	インド	インドネシア	韓　国	マレーシア	パキスタン	フィリピン	スリランカ	タ　イ	ベトナム	台　湾	（日本）
国家予算（億ドル）	37	661	534	234	440	118	100	93	37	179	13	301	5,320
○ 一人当り国家予算（ドル）	31.1	56.5	60.2	120.0	996.6	641.0	82.2	138.6	209.9	310.6	18.9	1,441.7	4,274.5
輸入（億ドル）	36	763	252	258	810	387	79	123	30	390	19	720	2,330
一人当り輸入（ドル）	30.3	65.2	28.4	132.3	1,834.7	2,102.1	64.9	183.3	170.2	676.8	27.6	3,448.6	1,872.1
輸出（億ドル）	16	805	202	295	720	354	60	87	23	275	18	810	3,390
一人当り輸出（ドル）	13.4	68.8	22.8	151.3	1,630.8	1,922.9	49.3	129.6	130.5	477.2	26.1	3,879.7	2,723.8
可　耕　地　（％）	67	11	57	8	22	13	26	26	16	34	23	25	13
○ 粗鋼生産（百万トン）		70.4	16.3	3.0	26							10.9	109
○ 一人当り粗鋼生産（kg）		60.2	18.4	15.4	588.9							522.1	875.8
○ 1000人当り乗用車（台）	0.34	1.37	2.59	6.67	45.30	97.77	6.07	6.76	9.81	11.37	1.45	124.53	297.28
○ 1000人当り商用車（台）	0.45	3.51	1.58	7.69	29.45	22.11	1.41	11.67	8.28	26.03	2.90	31.28	181.58
○ 1000人当りテレビ（台）	3.2	125.0	22.7	41.7	204.1	111.1	16.3	113.6	40.0	58.8	32.3	312.5	555.6
○ 1000人当り電話（台）	1.75	11.2	5.0	5.81	303	125	7.6	16.7	9.8	24.4	1.8	333.3	434.8
○ 1000人当り新聞（部）	8	37	21		309	145	9	44		50	38	202	585
○ 識　字　率　（％）	47	70	48	85	96	80	35	88	90	89	88	90	99

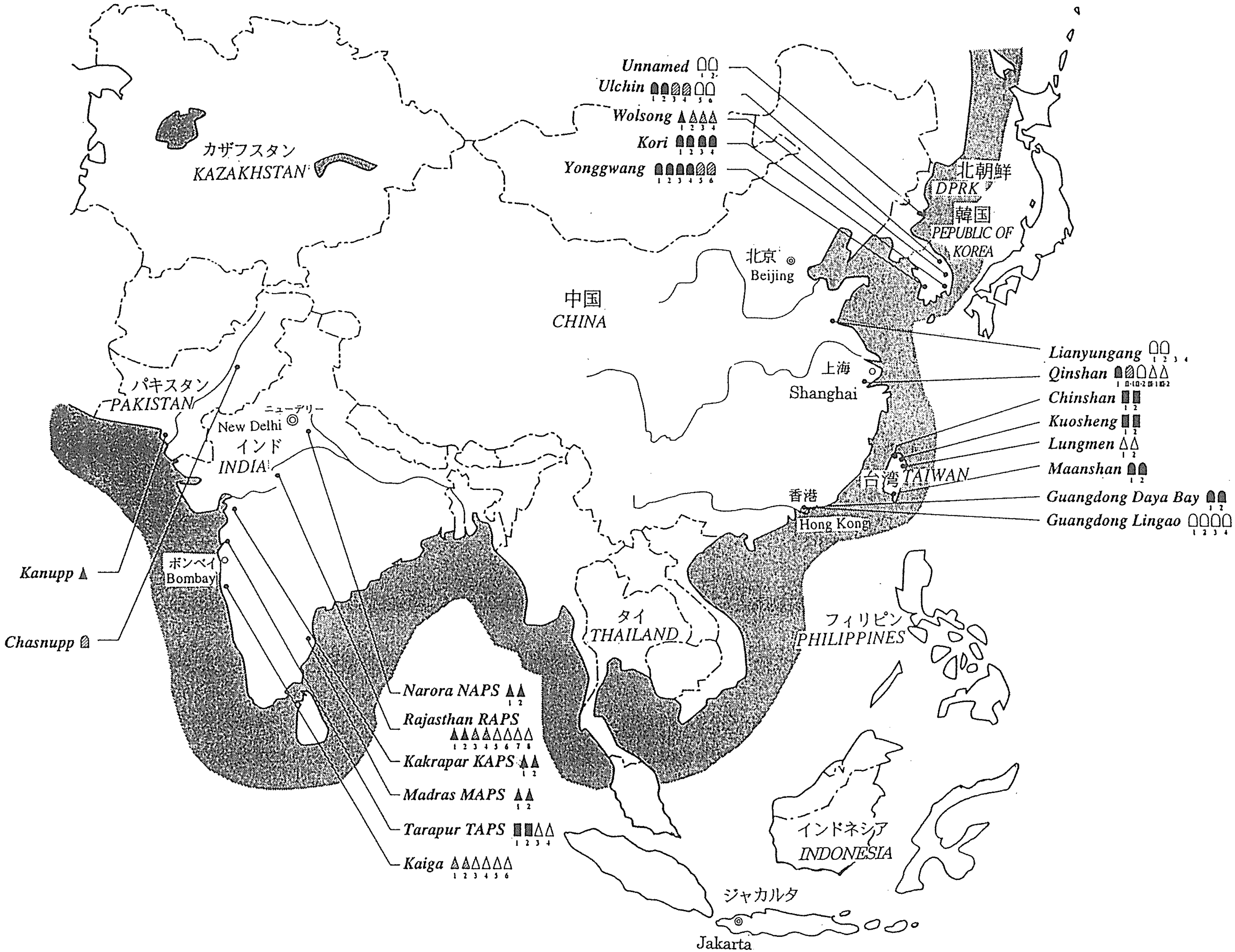
World Almanac 1994

第１６表　アジアの基礎指針とエネルギー需要

			ﾊﾞﾝｸﾞﾗﾃﾞｼｭ	中国	インド	ｲﾝﾄﾞﾈｼｱ	韓国	ﾏﾚｰｼｱ	ﾊﾟｷｽﾀﾝ	ﾌｨﾘﾋﾟﾝ	ｽﾘﾗﾝｶ	ﾀｲ	ベトナム	台湾
1人当り商業エネルギー消費量1)(KOE)			64	622	236	303	2,090	1,029	267	249	123	523	104	2,472
1人当り石油消費量(kg)			19	105	74	165	1,131	604	93	184	78	351	40	1,385
1人当り電力消費量(KWH)			42	509	223	154	2,205	1,118	260	340	153	681	89	4,091
エネルギー消費構造%	石油		29.8	17.0	30.6	71.8	54.1	58.7	34.7	74.0	63.6	67.2	40.5	56.0
	非石油	ガス	60.8	2.0	5.8	18.4	2.9	28.9	39.6	0.0	0.0	19.4	0.8	2.9
		石炭	5.4	76.4	51.6	6.9	26.5	7.4	8.8	7.0	0.3	9.5	40.8	22.7
		一次電力 水力	4.0	4.6	10.9	2.4	1.8	5.0	16.6	10.0	36.1	3.8	17.9	3.7
		一次電力 地熱	0.0	0.0	0.0	0.5	0.0	0.0	0.0	9.0	0.0	0.0	0.0	0.0
		一次電力 原子力	0.0	0.0	1.1	0.0	14.8	0.0	0.3	0.0	0.0	0.0	0.0	14.7
発電容量 MW	石炭火力		1,418	101,845	47,147	6,970	3,700	4,368	4.833	405	272	6,446	2,214	3,675
	石油火力 天然ガス						7,362			2,733				5,209
	水力		230	36,046	18,695	2,095	2,340	1,427	2,897	2,149	1,017	2,274	72	2,563
	原子力		0	0	1,565	0	7,616	0	137	0	0	0	0	5,144
	地熱		0	0	0	140	0	0	0	888	0	0	0	3
	合計		2,352	137,890	67,407	9,206	21,021	5,796	7,867	6,175	1,289	8,720	2,286	16,594

（アジア開発銀行報告）

アジアの原子力発電施設　（日本を除く）



アジアにおける原子力発電開発動向
NUCLEAR POWER PLANTS IN ASIA

単位：万kW、10MWe

国・地域 Countries・Region	運転中 OP		建設中 UC		計画中 PL		合計 TOTAL	
	出力 Output	基 Unit	出力 Output	基 Unit	出力 Output	基 Unit	出力 Output	基 Unit
日本 JAPAN	4,271.2	51	364.1	4	192.5	2	4,827.8	57
韓国 R KOREA	961.6	11	610.0	7	200.0	2	1,771.6	20
台湾 TAIWAN	514.4	6			270.0	2	784.4	8
中国 CHINA	226.8	3	60.0	1	1,000.0	11	1,286.8	15
インド INDIA	184.0	10	88.0	4	588.0	12	860.0	26
パキスタン PAKISTAN	13.7	1	32.5	1			46.2	2
北朝鮮 DPR KOREA					200.0	2	200.0	2
	6,171.7	82	1,154.6	17	2,450.5	31	9,776.8	130

アジアの基礎指標（Ⅰ）
BASIC INDEX NUMBER OF ASIA（Ⅰ）

	中　国 CHINA	ｲﾝﾄﾞﾈｼｱ INDONESIA	韓　国 KOREA	ﾏﾚｰｼｱ MALAYSIA	ﾌｨﾘﾋﾟﾝ PHILIPPINES	ﾀｲ THAILAND	（日本） JAPAN
人口(1994) （百万人、Million) Population (Million)	1,190.9	190.4	44.5	19.7	67.0	58.0	125.0
一人当たり GNP(1994) ドル、$ GNP/Capita	530	880	8,260	3,480	950	2,410	37,930
GNP成長率（%） 1985－94 GNP Growth Rate	7.8	6.0	7.8	5.6	1.7	8.6	3.2
一人あたりのエネルギー 消費　KOE(1994) Energy Consumption /Capita	647	393	3,000	1,711	364	770	3,825

アジアの基礎指標（Ⅱ）
BASIC INDEX NUMBER OF ASIA（Ⅱ）

	中国 CHINA	ｲﾝﾄﾞﾈｼｱ INDONESIA	韓国 KOREA	ﾏﾚｰｼｱ MALAYSIA	ﾌｨﾘﾋﾟﾝ PHILIPPINES	ﾀｲ THAILAND	（日本） JAPAN
一人あたり粗鋼生産 （百万トン,Million ton） Steel Production /Capita	70.4	3.0	26	—	—	—	109
一人あたり 国家予算（$） National Budget /Capita	56.5	120.0	996.6	641.0	138.6	310.6	4,274.5
千人あたり 乗用車（台） Private Cars/ 1000 People	1.37	6.67	45.3	97.77	6.76	11.37	297.28
千人あたり テレビ（台） TVs/ 1000 People	125.0	41.7	204.1	111.1	113.6	58.8	555.6
識字率 （%） Literacy Rate	70	85	96	80	88	89	99

原子力をめぐる地域協力と地域安定

米国エネルギー省核不拡散安全保障局国際政策分析室室長代理
E．フェイ

原子力の地域協力について、地域の安定化という観点から論じることとする。

アジア北東部は、政治的に緊張した不安定な地域である。同地域の諸国の原子力活動は、しばしば地域の安定を脅かしてきた。核兵器武装を幾度も考えてきた国もあり、同地域は核拡散の危険が大きい。

保障措置を受けずに進められてきた北朝鮮の原子力計画は、地域的に大きな不安定要因になっていた。しかし、関係国間で枠組みについて合意が得られ、朝鮮半島エネルギー開発機構（ＫＥＤＯ）が創設されたことによって、協力と安定化に向けて状況を転換することができた。

地域協力はＫＥＤＯおよび枠組み合意の事例を土台にすべきである。

核燃料サイクル関連の活動は、地域内の対立要因にするのではなく、安定化および協力関係を促進するために利用すべきである。そのためには、技術的な方策と政治的な方策が考えられる。両方策は調整すべきだが、それぞれ独自に進めることができる。

技術的方策は、電気事業者、準政府機関、研究機関、民間人、政府など、様々な機関によって実施できる。以下に例を挙げる。

- 原子力安全協力
- 使用済み燃料管理の協力
- 原子力活動の透明性の改善（相互訪問、研究会、検証実験など）
- 電気事業者グループや原子力産業界の国際的な意見交換
- 核物質管理の標準化
- ＫＥＤＯ
- 寧辺での米国と北朝鮮の協力関係

政治的方策によって、地域協力のための舞台や枠組みを作ることができる。

- ＡＰＥＣやＡＲＦの会議宣言
- １国、２国間、および多国間による原則の宣言
- 国際協定
- 特定の技術的措置を管轄できるような Pacificatom などの国際機関国際的な原子力協力では、原子力産業界の利益のみを追求するのではなく、地域諸国間の理解と関係改善にも貢献すべきである。

Asian Regional Stability and Nuclear Fuel Cycles

Comments by Edward Fei
U.S. Department of Energy
to
Japan Atomic Industrial Forum
April 11, 1997

Asian Regional Stability and Nuclear Fuel Cycles

Asian Regional Stability

Since WWII Northeast Asia has been a region of considerable instability and the region with the greatest risk of large-scale nuclear weapons proliferation. Sources of instability include: the Korean War, wars in Vietnam, confrontations over the status of Taiwan, the lack of peace treaties to finally end WW II and the Korean War, divided countries, rising nationalism, increasing military expenditures, and a lack of a regional security framework.

In such a situation, perhaps the most important goal for Northeast Asian states is to avoid conflict and to build a regional security architecture that will be the foundation for economic growth and trade.

The question I will address is, what are the implications of nuclear fuel cycles in Asia upon Asian regional stability? Is the region more stable or less stable because of nuclear programs?

The Effect of Nuclear Programs on Regional Stability

The simple fact is that nuclear activities of states in Northeast Asia have at times greatly contributed to regional instability and tension. Today there are three nuclear weapons states in Asia - Russia, China, and the United States. However there have also been repeated efforts by other states in the region to acquire nuclear weapons. Had these efforts succeeded, Northeast Asia might have been the location of a half dozen nuclear weapons states instead of only three. For example, as late as 1970 Australia, which is today a strong supporter of the nuclear nonproliferation regime, was giving serious consideration to the acquisition of nuclear weapons.

While the story is not over, it is possible to see Northeast Asia as a nuclear weapons nonproliferation success story. Despite the very high risk of nuclear weapons proliferation, it has not yet occurred. It is important to note that the so-far successful efforts to prevent nuclear weapons proliferation have relied not only on the so-called nuclear nonproliferation regime, but more significantly on the *ad hoc* bilateral and multilateral responses of individual states.

The Framework Agreement and KEDO

The most recent example of such an *ad hoc* effort is the Framework Agreement and the creation of the Korean Energy Development Organization (KEDO). I assume that most are familiar with the Framework Agreement in which the DPRK freezes its unsafeguarded nuclear activities and agrees in the future to undergo inspections in exchange for fuel oil and light water reactors.

The point to note is that a situation of grave regional security concern, unsafeguarded nuclear activities which would have provided materials for nuclear weapons, has been transformed into a situation in which nuclear cooperation is increasing, rather than decreasing regional stability. Americans from my office, at this very moment are working with North Korean technicians at Yongbyong, to can the spent nuclear fuel from North Korea's small gas graphite reactor. A North Korean delegation has been in the U.S. last month for briefings on possible four power talks. Additional meetings are planned.

The states of Northeast Asia should build on the example of the Framework Agreement and use it as a model for resolving certain types of regional problems by turning them into opportunities for regional cooperation.

What are some of the characteristics of the Framework Agreement that should be kept in mind when we look at it as a possible model? Without going into detail I would suggest the following:

- A threat or problem that many states wanted to be resolved
- A focus of attention on the problem
- Original thinking and leadership
- Hard Work
- International consultation and collaboration including the creation of KEDO
- An over-arching agreement in principle, the Framework Agreement, which is combined with specific technical activities - providing fuel oil, cleaning spent fuel storage ponds, canning spent fuel.

Pursuing this last point, what are some other agreements and activities involving the nuclear fuel cycle that might be used to enhance rather than undermine regional stability?

Specific Steps

Specific discrete actions that involve the nuclear fuel cycle and which increase regional stability, can be taken by a variety of different organizations. Of course governments can be involved, but in addition ministries, nuclear utilities, quasi-governmental organizations, laboratories, universities, think tanks, professional societies and non-governmental organizations can all be important contributors. Some examples of such activities include the following:

- Nuclear Safety Cooperation
- International exchanges among utilities and nuclear industries

- Exchanges of scientists or executives
- Verification and transparency experiments
- KEDO
- Regional safeguards and inspection regimes which might begin with site visits
- Regional approaches to the management of low level nuclear waste
- Regional approaches to the interim storage of spent nuclear fuel.

Political and General Steps

Political actions whether large scale or small, unilateral or multilateral, can help to create a framework which provides guidance and direction to more specific or technical actions. Actions that might be taken of this sort include:

- International Agreements
- Agreed statements of principle or declarations at meetings such as APEC or ARF
- International memoranda of understanding
- Unilateral or bilateral speeches
- Voluntary offers to cooperate or increase transparency
- The creation of international organizations such as a Pacificatom that might provide an umbrella for specific technical actions

In summary, it is important to think regionally as well as nationally. Planners in each country should think not just of domestic concerns, but of the international implications of fuel cycle activities. More far-seeing planners should ask how nuclear activities and cooperation might also contribute to the greater goal of regional stability.

ＫＥＤＯプロジェクトにおける韓国の役割と
地域の原子力発電協力に関する将来の見通し

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アジアは今日、原子力発電所（ＮＰＰ）建設計画の面で、世界中で最も活発な地域である。これは同地域の積極的な経済政策と、それに伴う電力需要が原因である。

天然エネルギー資源が不足している韓国において、原子力発電は重要な役割を果たしてきた。韓国は現在、１１基の原子炉を運転しており、発電設備容量は９．６ＧＷｅである。６．１ＧＷｅ規模の７基の原子炉を建設中であり、さらに２基の韓国標準型原子炉ＫＳＮ－１０００原子炉の建設を今年後半に開始する予定である。

ＫＳＮ－１０００（１００万ｋＷ）の設計は、韓国の原子力発電所の建設と運転の経験を反映するとともに、世界中から得られた教訓を活用するために開発された。韓国はより単純な設計、強化された安全機能、より効率的な運転特性を採用する次世代原子炉であるＫＳＮ－１３００（１３０万ｋＷ）の開発へと進むなか、原子力発電開発計画へのコミットメントを引き続き強めている。一方、韓国は「非核韓(朝鮮)半島平和」政策に従って、いかなるバックエンド核燃料サイクルプロジェクトも実施していない。

韓国は原子力開発の効率を改善するため、よりビジネス的な側面をもった取り組みを推進することにより、原子力産業の再編成を行った。これに伴い、「ＮＳＳＳ設計」作業は韓国原子力研究所（ＫＡＥＲＩ）から韓国電力技術（ＫＯＰＥＣ）に、「放射性廃棄物の管理」はＫＡＥＲＩから韓国電力公社（ＫＥＰＣＯ）に、また「核燃料設計」はＫＡＥＲＩから韓国原子燃料（ＫＮＦＣ）に引き継がれた。政府、産業界、高等教育機関および研究センターの積極的な参加を得て研究効率を最大化するため、中・長期的な研究開発計画が設定された。

韓国はＩＡＥＡ、ＲＣＡ、ＷＡＮＯ、ＰＢＮＣ等に参加し、政府と電力会社の両方のレベルで参加者間の教訓、研修、技術支援を共有することにより、地域における原子力の平和利用を促進している。これらの地域協力の中で、最も重要な協力プロジェクトが軽水炉（ＬＷＲ）プロジェクトである。

周知のとおり、ＬＷＲプロジェクトはそれぞれ約１００万ｋＷのＫＳＮＰを２基、国際コンソーシアム・朝鮮半島エネルギー開発機構（ＫＥＤＯ）によって北朝鮮（朝

鮮民主主義人民共和国）に供給するものである。現在のところ、ＫＥＤＯは当初の加盟国３国（すなわち、日本、米国および韓国）、および７つの加盟国（すなわち、アルゼンチン、オーストラリア、カナダ、チリ、フィンランド、インドネシアおよびニュージーランド）で構成されており、ＥＵの加盟が暫定的にＥＵとＫＥＤＯとの間で合意されている。

ＫＥＤＯはターンキー方式によるＬWRプロジェクトの主契約者としてＫＥＰＣＯを正式に指名した。ＫＥＰＣＯは主契約者として、ＫＳＮＰを数多くの各種原子力プロジェクトを通じて得た建設経験と技術力をもとに、所定の期間内に建設するため、最善の努力を現在も今後も払い、「韓国の中心的な役割」になりつつある。

北朝鮮と韓国の微妙な関係により、またプロジェクトスポンサーの政治的、商業的利害が入り交じっているため、 ＬWRプロジェクトは、非常に複雑で困難である。本プロジェクトにはプロジェクト参加者の密接な協力が必要であり、プロジェクトの実施期間のみならず、発電所の運転中も、日本の格別の理解と積極的な協力が不可欠である。これを念頭に置き、私は本プログラムが北朝鮮によるＮＰＰの安全な運転のため、アジア諸国の非政府組織（ＮＧＯ）のレベルで技術と人材を北朝鮮と交流する道筋を描くことで、このフォーラムが原子力安全性を確保するための地域協力機関を作り上げる良い機会となることを期待したい。

The Role of Korea in the KEDO Project and Future Prospects in Regional Nuclear Power Cooperation

– Annual Conference of the Japanese Atomic Industrial Forum –

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In the world today, there are four hundred thirty-seven (437) nuclear units in operation and thirty-nine (39) units under construction, and in Asia eighty-two (82) nuclear units in operation and fifteen (15) units under construction. Many countries in the Asia Region are expected to construct more nuclear units early in the twenty-first (21th) century, considering their aggressive economy driving policies and their accompanying demands for electric power. Accordingly, the Asia region is expected to be the most active area in the world for nuclear construction.

Korea imports most of its required energy from foreign countries due to its deficit in natural resources. So, we have chosen the nuclear development program to meet the energy demand for continuing economic growth. Korea has been performing nuclear project most vigorously since early eighties (80's) and is one of the nations that operate Nuclear Power Plants (NPPs) most safely and successfully in the world. Presently, we have eleven (11) Nuclear Power Plants (NPPs) in operation which generate nine point six giga-watt (9.6GW), and four (4) KSN one thousand (KSN-1000) units and three (3) CANDUs under construction which generate six point one giga-watt (6.1GW). Moreover, we will start construction of two (2) more Korean Standard Nuclear Power Plants (KSN-1000) in Ulchin late this year. According to the long term power development program established in nineteen ninety-five (1995), Korea's nuclear power capacity is expected to be enlarged to twenty six point three giga-watt (26.3GW) by the year twenty-ten (2010).

With the aim of design and construction of the standard nuclear power plant (NPP) which fits with Korean, we have successfully developed the KSN one-thousand (KSN-1000), utilizing our construction and operation experiences gained through previous projects as well as adopting various new technologies from around the world. Furthermore, we have commenced the KSN thirteen hundred (KSN-1300) project as a next generation reactor with the aim of promoting the nuclear capability of Korea to the level of developed countries. The KSN thirteen hundred (KSN-1300) design is being developed with the target of operation in the year twenty-o-seven (2007). The KSN thirteen hundred (KSN-1300) will have greatly increased the safety and economy by adopting the concept of facility simplification, the increased capacity factor, the extended lifetime and other design features. Meanwhile, we do not perform any back-end nuclear fuel cycle projects according to the "Non-Nuclear Korean Peninsula Peace" policy.

The nuclear project organization in Korea was established in mid eighties (80's) to rapidly achieve technology self-reliance and this purpose was achieved successfully by late nineteen ninety-five (1995). In late ninety-six (1996), a more businesslike nuclear project organization was formulated to escalate the competition capability of our nuclear industry based on attained technology self-reliance. As results, the "Nuclear Steam Supply System (NSSS) design" task was turned over from KAERI, which stands for Korea Atomic Energy Research Institute, to KOPEC, which stands for Korea Power Engineering Company, and "radioactive waste management" from KAERI to KEPCO, and "nuclear fuel design and CANDU fuel fabrication" from KAERI to KNFC, which stands for Korea Nuclear Fuel Company. Mid & long term R&D plan has been set up to maximize research efficiency with the positive participation of government, industries, institutes of higher learning and research centers.

Korea has been promoting the peaceful use of nuclear energy in the region by joining the IAEA RCA, which stands for Regional Cooperative Agreement for Research, Development and Training Related to the Nuclear Science and Technology for the Asia and Pacific Region, in nineteen seventy-four (1974) and by cooperations among the members. Also, Korea shares the common understanding on peaceful nuclear power by attending "The International Conference for Nuclear Cooperation in Asia" which is held at the governmental level and by improving the safety and credibility of NPP through cooperation such as sharing lessons learned, training, technical support by participating the WANO, PBNC at the level of power companies. Among these regional cooperations, the LWP Project is one of the most important cooperative project.

As you might well know, the LWR project is to supply two (2) KSNP of approximately one thousand mega-watt-electric (1,000MWe) each to the DPRK by international consortium (KEDO). At present, KEDO is composed of three orignal members (that is Japan, USA and ROK) and seven (7) member countries (that is Argentina, Australia, Canada, Chile, Finland, Indonesia and New Zealand), and the accession of European Union (EU) is agreed provisionally between EU and KEDO.

KEDO officially designated KEPCO as the prime contractor of the LWR Project on a turnkey basis. As the Prime Contractor, KEPCO is exerting and will continue exert its best efforts, becoming to the "Central role of Korea", to successfully construct the "KSNP" within given time span with its construction experiences and technical capabilities developed through many different nuclear projects.

The LWR Project is very complex and difficult due to the delicate relationship between the DPRK and the ROK, and the mixed political and commercial interests of the project sponsors. The LWR project is an unprecedented peculiar project which is being carried out under the leadership of KEDO and jointly sponsored by Korea, Japan, USA and other member countries, and at the same time it is a project which is commonly pushed by Government and private sector, having features of both a regional cooperative project and an international project. I might add that, therefore, the member states of KEDO are playing an important role in maintaining peace on the Korean Peninsula and greatly helping the promotion of regional interests by taking part in the settlement of "safe and peaceful nuclear power" in Asia.

therefore, the LWR project will require close cooperation among the project participants not only project implementation but also plant operation. Although the companies to be participated in the LWR project have not been selected, many companies of Japan are expected to join this project. In this regard, the special understanding and positive cooperation of Japanese Atomic Industry is indispensable for the successful completion of the LWR project. As the international circumstances of nuclear power will be varied greatly in the forthcoming twenty-first (21st) century, I suppose it is time for us to promote the international and regional cooperation one step further and we are in a position that we have to investigate a cooperative program for the nuclear safety regulation and operation of the DPRK, which we cannot even access presently.

Finally, I would like to suggest that this forum be a good chance to compose a regional cooperative body to secure the nuclear safety by plotting a course for the program to exchange technology and manpower with the DPRK at the level of non-government organization (NGO) among the countries in Asia for the safe operation of the NPP by the DPRK.

インドの原子力発電開発

インド原子力産業会議会長
Y. S. R. プラサド

インドは独立民主国家である。その人口は独立当時の３億人に対し、１９９６年には９億４，０００万人であった。人口の約７０％は農村地域に住み、多くが農業に依存している。現在の３８０ＫｇＯｅというエネルギー消費量の４０％は木材、農作物の残り等のバイオマスから得られている。インドはエネルギー資源、特に石油ガス資源の面で恵まれておらず、エネルギーの純輸入国である。

電力は商業用エネルギー消費量の約７％を構成する。１人あたりの電力消費量は年間３１０ｋＷｈである。電力の伸び/需要は過去数十年間９－１０％の割合で成長しており、今後は年率６－７％で成長するものと見られる。現在の設備容量は８，６００万ｋＷであり、そのほとんどが石炭火力発電所によるもので、原子力発電は１５４万ｋＷにすぎない。

長期的には、インドのエネルギー政策は３６万トンという厖大なトリウム資源の利用を目指している。原子力発電計画はこの目的を念頭に置いて遂行されてきた。インドは原子力発電プログラムに閉じられた燃料サイクルオプションを選択した。第１段階として、（１０万～２２万ｋＷ級）加圧水型重水炉（ＰＨＷＲ）が８基設置され、そのうち６基が運転中で、２基が改修中である。１９９８年までに、さらに４基の２２万ｋＷ原子炉が運転を開始する見込みである。また、２２万ｋＷが４基、５０万ｋＷが６基のＰＨＷＲを設置する準備作業が行われている。さらに、ロシアの協力を得て、１００万ｋＷのＶＶＥＲを２基追加することも計画中である。プログラムの第２段階も着手されている。ＦＢＴＲ（熱出力４万ｋＷ）が運転されており、５０万ｋＷの高速増殖炉原型炉の設計が完成しており、まもなく立ち上げられる予定である。これに加えて、ウラン２３３を使用する３万ｋＷの研究炉が最近試運転を開始した。

インドは国際的な原子力規格に適合する原子力発電所の設置に必要な各種機器を生産する製造能力を開発した。また、採鉱から燃料の製造、再処理、およびＭＯＸとトリウム燃料集合体の製造までの、完全な燃料サイクルをマスターしている。インドはまた、重水生産技術および廃棄物管理技術もマスターした。インドが原子力発電に関わるいくつかの技術事項についてかつて直面し、いまだに直面している禁輸のゆえに、これをインドは独力で遂行しなければならない。

インドの原子力発電プログラムは、国内電力需要を満たすためのみならず、技術の輸出に着手することができ、加速的な成長へ対応するための、安全で経済的な選択肢として成熟している。

我が国の原子力発電プログラムは経済危機のために成長しなかった。他のインフラストラクチャーとは異なり、技術管理体制があることから、外国の技術と国際金融機

関からの低利長期の借款によって原子力発電所を建設するという方式は、原子力部門では利用できない。

これまで、原子力発電はインド政府が所有し、大部分が政府の出資によるものであり、短期満期の債券による公衆からの資金には限りがあった。このプログラムはインド原子力発電公社（ＮＰＣＩＬ）/原子力省（ＤＡＥ）によって実施されてきた。インドの原子力発電プログラムは、経済危機と公衆からの資金借り入れの制限のため、所要のペースで成長することができなかった。しかし、原子力発電が将来果たすべき大きな役割を考えると、プログラム実施の他の各種オプション／可能性を検討することが不可欠となった。

インド原子力産業会議（ＩＡＩＦ）は、ＮＰＣＩＬ、ＤＡＥおよびその他の構成機関、原子力産業、研究開発機関、コンサルタント・金融機関の団体であり、原子力発電プログラム実施の促進のための各種オプション／可能性に取り組むことを主たる目的として最近設立された。検討対象となりえる各種オプションには、次のものが含まれる。

ａ）サプライヤーズ・クレジットによる産業界からのローン

ｂ）インド／外国双方の民間関係者からの持株による参加

ｃ）ＮＰＣＩＬ／ＤＡＥがプロジェクトの原子力部分のみに責任を持ち、従来のシステムとユーティリティ系はもう一方の当事者が責任を持つという、共同所有

ｄ）前記の（ｃ）と併せて、前記と同じ境界の設定による、プロジェクトの管理全体、およびその後の発電所の運転

また、インド原子力産業会議は、相互協力と技術援助を実施することにより、核科学、原子力技術および発電の分野で開発途上国および先進国との協調を確立し、それを増進したいと考えている。また、ＩＡＩＦはさまざまな国際機関、業界団体、および同じような活動に従事する機関ならびに原子力発電プログラムを有する国々または原子力発電プログラムを計画する国々と密接な連絡を確立し、維持したいと考える。

ENERGY SCENARIO IN INDIA

The total energy consumed in India, both commercial as well as non-commercial form per capita is around 380 KgOe. Forty percent of the energy (non-commercial) is derived from bio-fuels, such as, fuel wood, crop residue and animal waste. Thus the primary commercial energy per capita consumption is about 235 KgOe. The energy demand has grown at 6% per year in the last two decades and the growth rate is expected to be 6-7% per year upto 2020.

The India's population has grown from mere 300 million at the time country gained independence to 940 million (1996) and with the projected growth rate, it is expected to double by 2047 AD and attain hypothetical stationary level of 1880 million.

India has made rapid strides in capacity addition. The installed capacity has risen to 86,000 Mwe from a mere 1400 Mwe at the time of independence.

The present installed capacity is about 86,000 Mwe (utility & non-utility) constitutes of Thermal 73%, Hydel 25% and Nuclear 2%. The country's per capita electricity consumption is 310 Kwh, which is very low, and is 40 times less than that of Latin American countries and 8 times less than that of world average. The demand for electricity has grown at a rate of about 9 to 10%, in past decades and is expected to grow further at a rate of 6 to 7%.

As per the projection made by various agencies based on various assumptions, GDP growth rate and HDI, an installed capacity of about 400,000 will be required by the year 2020. However, a minimum capacity addition of 200,000 Mwe is required to be set-up by the year 2020, for maintaining sustenance at present level and a reasonable growth.

India is poorly placed in terms of world energy resources, while 16% of world population lives in India, only 0.6% of oil and about the same portion of gas reserves exists in the country. However, India is endowed with 6% of coal reserves of the world. India is net importer of energy. As per the present projections the proven reserves of coal are expected to last for 100 years. The oil and gas would last for 24 and 23 years, respectively. Moreover, oil, gas and coal also have non-energy uses. The hydel and coal reserves are concentrated in certain regions of the country.

Based on the Uranium resources available in the country, it will be possible to build a maximum of about 10,000 Mwe of PHWR capacity. However, by adopting the Fast Breeder Technology, it is possible to build a Nuclear Power capacity of about 300,000 MWe by using vast resources of 360,000 tonnes of Thorium.

As the projected demand is considerably high, there is a need for development of diversifying energy resources. However, nuclear power will have to play an increasingly important role in long term energy management. An installed capacity of about 10% by the year 2020, i.e. 20,000 MWe should be added by Nuclear Power.

India's nuclear power programme

Indian nuclear power programme commenced with the construction of Tarapur Atomic Power Station (TAPS-1&2) with 2 x 160 Mwe (present capacity) Boiling Light Water Reactors (BWRs), using enriched Uranium as fuel and light water as moderator, set-up in 1969, on a turn-key basis, by General Electric Company, USA. These two units were set-up essentially to demonstrate the technical viability of operating them within the Indian regional electric grid system, which was at that time relatively small. These Units also helped us to gain valuable experience in operation and maintenance of nuclear power plants. After more than twenty-five years of safe and successful operation, these reactors are still in service, providing much needed electricity to the Western Grid.

From the very beginning, as a long term strategy, the nuclear power programme formulated by Dr Bhabha, embarked on a three stage nuclear power programme linking the fuel cycles of PHWR and LMFBR, was planned for judicious utilisation of our limited and low grade (< 0.1% U_3O_8) Uranium ore (78,000 tonne) but vast thorium resources (> 360,000 tonnes). The emphasis of the programme was self-reliance and thorium utilisation, as a long term objective. India has selected Pressurised Heavy Water Reactor (PHWR), because of several inherent advantages -

a) PHWR uses natural uranium as fuel, natural uranium being easily available in India, helps cut heavy investment on enrichment, as uranium enrichment is capital intensive.

b) Another reason is that the natural uranium requirement for PHWR is the lowest and plutonium production is highest.

c) Finally, the infrastructure available in country was suitable for undertaking manufacture of equipment for PHWR Reactor.

The three stages of our Nuclear Power Programme are :

Stage-I envisages, construction of Natural Uranium, Heavy Water Moderated, Pressurised Heavy Water Cooled Reactors (PHWRs). Spent fuel from these reactors is reprocessed to obtain Plutonium.

Stage-II envisages, construction of Fast Breeder Reactors (FBRs) fuelled by Plutonium produced in Stage-I. These reactors would also breed U-233 from Thorium. It is also planned to develop an advanced heavy water thermal reactor (AHWR), as an extension of Stage-I PHWR programme. The AHWR, using a Pu-239 enriched Uranium fuel in the driver (booster) zone and U-233 enriched Thorium fuel in the driven zone, would generate a large part of its energy output from Thorium through fission of insitu bred U-233.

Stage-III would comprise power reactors using U-233 / Thorium as fuel.

In order to be self-reliant in the field of nuclear power generation, the Department of Atomic Energy, opted for 'CANDU' technology in collaboration with Atomic Energy of Canada Limited, and commenced construction of a power station comprising two units of 220 MWe at Rawatbhata in Rajasthan in 1964. The 'CANDU' technology involved the use of Natural Uranium as fuel and Heavy Water as moderator. To achieve self sufficiency in this field in the long run, the Department of Atomic Energy established facilities for fabrication of fuel and Zirconium alloy components, manufacture of precision reactor components and production of Heavy Water. Momentous efforts were put in to develop manufacturers in the country to produce components like Calandria, End-Shields, Steam Generators, fuelling machines, Nuclear pumps and other critical equipment, required for setting up of nuclear power stations, conforming to International Nuclear Standards. Development of world class manufacturing facilities in public and private sector organisations was achieved.

Rajasthan units were followed by two more units at Kalpakkam near Madras. Thus, the first stage program with short term goals of complementing generation of electricity at location away from coal mines progressed steadily.

The erstwhile Nuclear Power Board, was incorporated as Nuclear Power Corporation, in the year 1987, with an aim to accelerate first stage of nuclear power program, by having access to the finances from the market.

With the evolutionary changes taking place with the development of the Nuclear Power Plants to meet seismically qualified equipment and systems coupled with new safety criteria, improved designs were developed and implemented at the Narora Atomic Power Plant (NAPP) at U.P. The 220 MWe design was also standardised. The innovation and improvements implemented at the Nuclear Power Plant, involved considerable efforts in research & industrial infrastructure in the country. This, India has to achieve all by itself in view of various embargoes it faced and still faces in several technological matters concerned with nuclear power. Successfully commissioning of Narora Atomic Power Station (NAPS) established total capabilities for design, construction, fabrication of equipment, operation and maintenance of Nuclear Power Plant in India. In the process, a good industrial infrastructure has been created in the country for nuclear power program. Self-reliance has been established in the reactor technology in all its aspects. Subsequent to Narora, two more atomic power stations at Kakrapar have been built and commissioned in the shortest possible time, using the indigenous technology. By successful commissioning of KAPS, Kakrapar, it was once again demonstrated that India has matured in this technology and is fully capable of exploiting the same. This also established nuclear power as safe, environmentally benign and economically viable source of power generation, its cost comparable with coal based thermal plants.

With the second unit in KAPS at Gujarat, achieving commercial operation from September, 1995, Nuclear Power Corporation of India Limited (NPCIL) has attained an installed power capacity of 1840 MWe.

Plants under construction

Presently, four units, of 220 MWe, namely - Kaiga-1&2, near Karwar and RAPP-3&4 in Rajasthan, are in the advanced stage of construction.

Future programme

With a view to augment the growth of nuclear power and PHWR system, and also eventually realise the economy of scale, it was necessary to design a larger PHWR system, 500 MWe PHWR was evolved to fulfil this need The design for 500 MWe are ready and we are well set to get on with the construction of 500 MWe PHWR units, with the first units at Tarapur. Sites for setting up of 6 x 500 MWe (PHWR), (4 units at Rajasthan & 2 at Tarapur) and 4 x 220 MWe (Kota, Rajasthan), have been cleared and advance action for developing infrastructure and procurement of long delivery items has been taken up.

Nuclear power program in India, has addressed all aspects that are of concern to public which mainly relate to safety, management of high level and long lived radio-active wastes. Safety standards followed in nuclear installations high and generally in line with that of international norms. All the technical aspects associated with the handling of the wastes have been addressed.

Both the old (Tarapur, Rajasthan & Madras) and new generation nuclear power stations (Narora & Kakrapar), have performed very well attaining cumulative life time capacity factor near to normative value and selling power at competitive rates. Recently, nuclear power plants crossed generation of one lakh million units mark. The 120 reactor years of operating experience has been free of any incident leading to release of radio-activity into the environment. While operating these plants, number of challenging maintenance activities have also been handled successfully by developing indigenous technology.

A beginning has been made for the second stage of nuclear power program with the setting up of a Fast Breeder Test Reactor (FBTR) at Kalpakkam, and recent commissioning of a 30 Kwh research reactor "KAMINI", which uses Uranium 233 as fuel. It is planned to set up one unit of 500 MW(e) Prototype Fast Breeder Reactor (FBTR), the design of which is fast progressing.

India has also mastered fuel cycle technologies, from mining to fabrication of natural uranium fuel, fabrication of enriched uranium fuel, reprocessing technology, fabrication of Plutonium and Thorium based fuel required for our future program. All the technological aspects related to short term and long term storage of nuclear waste have been appropriately addressed. The related waste management facilities have also been satisfactorily developed.

To summarise, the concerted efforts put in by Department of Atomic Energy (DAE) and its constituent units together with Indian industries and institutions have led to development and full capabilities to design, manufacturing of equipment, construction, operation and maintenance of nuclear power plant. Today India is amongst the select band of few countries of the world who have developed such capabilities.

India's nuclear power programme has now matured as a safe and economical option for not only meeting the country's power demand, but also can embark on exporting the technology, and it is poised technologically for an accelerated pace of growth.

Notwithstanding the indigenous developments, the light water reactors have been the mainstay of nuclear power programmes in most countries. These were offered as possible international projects in the past. Presently, India is considering the offer of the Russian Federation for two 1000 MWe VVERs to be built by 2008-2009. Similar additions to our nuclear power programme in terms of additional LWRs of advanced designs from international projects can be considered to augment nuclear power programme in the coming decades. This is, of course, assuming that the terms of offer are appropriate to the Indian context.

Problems faced

1. In most of the countries development in Nuclear Power sector have been achieved by international co-operation supported by funding credit. However, the innovations and improvements incorporated by India in its standardised 220 MWe PHWR (Narora onward) involved considerable efforts in research and development, as well as, technological improvements in the industrial infrastructure in the country: This, India had to achieve all by itself in view of various embargoes it faced and still faces in several technological matters connected with nuclear power. It is because of this, that earlier plants took somewhat longer period of gestation. We are also facing similar

difficulties in developing technologies for inservice inspection, life extension programmes and spares for imported plants. We are in a position to develop all related technologies and recent coolant channel removal work from Unit-2 of Rajasthan, within a reasonable time and manrem consumption, has amply demonstrated our capabilities.

Nuclear Power, which has proved to be a cleaner source of power and is not associated with emission of any harmful gases associated with global warming and acid rain, is expected to play significantly larger role in meeting the electricity demands. It is worth mentioning that, Nuclear Power generation in any part of the globe will not only serve that region, but should be considered as an essential element in the global energy policy.

2. The country's nuclear power programme has not grown due to financial crunch. Unlike other infrastructure, proposals to set-up nuclear plants with foreign technology and soft term loans from the international financial institutions, is not available for the nuclear sector due to technology regime control. Financial borrowings from the domestic market are for a limited period of five year only. It is too short a period considering gestation period for power plants, even at international level. This also leads to a vicious circle where further borrowing becomes inevitable to pay the previous debts, more so, when new capacities are to be added. As for a nuclear power station, it takes 10-12 years to repay the loans after commencement of operation of plants. Long term financing from the Pension fund / Provident Fund, and similar such funds, should be considered.

3. So far, the nuclear power has been owned and largely funded by Government of India, with limited finances from public, in form of short term maturity period bonds. The programme has been implemented by Nuclear Programme Corporation / Department of Atomic Energy. The nuclear power programme in India could not grow at the desired pace due to the financial crunch and limitation of borrowing money from the public. However, in view of larger role which nuclear power has to play in future. It has become imperative to consider various other options / possibilities of implementing the programme.

Indian Atomic Industrial Form (IAIF), an Association of NPCIL, DAE and its other constituent units, Nuclear industries, R&D organisations, Consultancy and financial institutions, has been launched recently with a prime objective of working on various options / possibilities for accelerated implementation of Nuclear Power Programme. Various options which can be considered are :

a) Loans from industries in the form of suppliers' credit.

b) Equity participation from private parties, both Indian / foreign.

c) Joint ownership, with NPCIL / DAE being responsible, only for nuclear island of the project and the entire conventional and utility system with other partner.

d) Entire project management together with (c) above - and further operation of the plant with similar areas of demarcation.

Indian Atomic Industrial Forum would also establish and enhance co-ordination with the developing and developed countries in the areas of nuclear science, technology and power by providing mutual co-operation, and technical assistance. IAIF would also establish and maintain close contact with various international agencies and industrial groups and organisations engaged in similar activities, and with countries having a nuclear power programme or planning to have one.

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STATUS OF NUCLEAR POWER PROGRAM IN INDONESIA

M. Iyos R. Subki
Director General, Batan - Indonesia
Presented at 30th JAIF Annual Conference, Tokyo 8 - 11 April, 1997.

1. INTRODUCTION

The demand for electricity grows continuously in every country, especially in developing countries. This increase goes along with the rate of population growth, economic development and rapid development of industrial sector. To fulfil this demand, it is becoming more difficult to depend on the existing resources due to their limited availability and logistic as well as environmental constraints.

It is, therefore, very important to take steps to seek other alternatives for large scale supply of energy, the requirements for the alternatives are among others : energy supply security, proven safety, technology provenness, economy, financialibility, and social cultural as well as environmental acceptability.

Based upon these considerations and supported by human resource and infrastructure development and also continuing public acceptance activities, the option of nuclear power can be the right alternative energy for the up coming energy mix scenarios.

With nuclear power within the energy mix, above requirements will be well guaranteed.Additionally, nuclear power in Indonesia will be developed to improve synergy of energy resources especially synergy between fissile and fossil fuels, and to enhance harmony of energy system with people and environment.

The demand for energy in 1995 was 1,311 MBOE and supply was 1,134 MBOE. This means there was already an energy deficit of 177 MBOE. In the 2020 the demand will be 2,168 MBOE and the supply will be 2,534 MBOE. The balance of supply and demand will be due to increase use of coal, nuclear and possibly geothermal, while oil and gas supplies will level off or decrease.

2. THE NATIONAL ENERGY POLICY.

The National Energy Policy is depicted in KUBE or the General Policy Guidelines for Energy Sector. Briefly , our energy policy has four main objectives, they are :

- to secure the continuity of supply of energy for domestic use at prices affordable to the public.
- to enhance the quality of life of the people.
- to stimulate economic growth.
- to reserve an adequate supply of oil and gas for export, as a foreign exchange source for national development.

There are three policy measures adopted by the goverment to achieve the objectives, they are :

- diversification : to reduce dependence on only one type of fuel and to include other alternatives.

- intensification : to increase and expand expolaration of energy resources available in the country.
- conservation : to economize energy production and utilization.

Implementation of energy policy covers several aspects such as issuance of regulations, standards, energy pricing incentives and disincerntives, and the application of appropriate technologies. The technologies that would be considered are identified as follows :

- Technologies to produce substitutes for oil, as oil is non - renewable. Gasification and liquefaction of coal could well meet the fuel needs of the future.
- Technologies to support a more sustainable energy supply, through the harnessing of our potential renewable energy sources.
- Clean and efficient energy technologies to support environmental programme and sustainable development.

3. FEASSIBILITY AND VIABILITY OF NUCLEAR POWER

Feasibility of Nuclear Power Plants from the following points of views has been confirmed through the Feasibility Study and Site Investigation which was completed in May 1996 :

- technology provenness
- safety acceptability
- economic viability
- fuel cycles feasibility
- decommissioning consideration
- site availability
- environmental and socio - cultural considerations.
- human resources availability and infrastructure considerations.

Based on this feasibility study and in congruence with our national energy policy, we have shown that nuclear power is essential for medium and long term supply of energy in
Indonesia.

The result of the feasibility study for the generation costs shows that the generation costs of conventional scheme for 600 - 900 Mwe class Nuclear Power Plants units are competitive to the generation costs of similar capacity of Coal Fired Plants using deSOX and deNOX. The generation costs of these NPPs vary from 48 mills/kWh to 61 mills/kWh, and for coal fired plants the generation costs are around 63 mills/kWh. Actually in the BOO scheme, the generation costs of coal fired plants are 82 mills/kWh for Paiton I and 64 mills/kWh for Paiton II.

4. PROBLEMS AND THEIR POSSIBLE SOLUTIONS.

We still have some outstanding problems in the effort to introduce the first NPP's in Indonesia, notably the problem related to organizational infrastructure, to a larger extent our problems are related to financing scheme and to a lesser extent to public understanding on nuclear power issues.

Through the new nuclear energy law which was passed in the parliament on 26 February 1997: BATAN will remain to be the organization for nuclear R & D fuel cycles development, nuclear safety technology development, nuclear services and promotion of nuclear energy. A separate and independent Nuclear Regulatory Body for the regulation of nuclear activities will soon be established. Meanwhile, Nuclear Power Company will also be proposed and established with the function of NPP's construction and operation.

Cooperation in the field of human resource development is definitelu required for the above organizations.

A more difficult problem is related with the financing scheme for the project. The government seems to require a loan which should be off the balance sheet of the government. Therefore, we are developing various financing schemes including: traditional, BOO, barter financings and combinations thereof.

We have now finalized the traditional and BOO schemes, while the barter or counter purchase scheme will be finalized by the end of 1997.

In the BOO schemes, vendors will still require some form of sovereign guarante, which the government cannot accept yet. The BOO schemes implies also additional costs and complexity, it requires some additional supports from the government notably in : public acceptance, third party liabilities, long term radioactive waste management and decomissioning. The need to share financial and non - financial risks at the side of foreign investors can require government participation in the form of partial equity. Then it would become essentially a modified BOO scheme.

Public information and education will form continuing activities for the promotion of nuclear energy applications. A special attention should be given to the impact of negative infomation given to the public by a small group of antinuclear activists. We think we should be cooperating in developing a new strategy to make a public acceptance program succesful. For this purpose we will redefine the following activities :

- redefinition of target audiences.
- developing methods of communication.
- topics for public education and discussions, taking into account the negative information given by antinuclear group.
- partners for undertaking the activities.

In general with above programs related to the financing scheme development and public information activities, and also with the success in getting the approval at the parliament on the new nuclear energy law, the nuclear power program in Indonesia is still on the track.

memo

memo

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発表は 4 月 10 日 午前 9 時 以降に願います。

EMBARGO UNTIL 9:00 a.m. April 10

§社会討論

原子力施設が嫌われるこれだけの理由

原子力資料情報室　高木仁三郎

1。危険性の認識の欠落。
原子力施設は潜在的に危険施設であり、放射性廃棄物の発生と合わせて、それ自体の本質において地域にメリットのない”迷惑施設”である。この点の基本認識を欠落させていることが多い。

2。金でその困難を回避しようとする。
各種の交付金や寄付は、結局「迷惑料」であり、原子力施設の地域へのメリットと称するものは、付随的なものにすぎない。大消費地で使う電力以外のもの、つまり地域への創造的寄与は、原子力施設にはない。

3。情報を公開しない。
政府や電力会社の情報公開が現在でもまったく不十分な事例は、数多く具体的に指摘できる。未だに、「広報」という枠組みで考えており、住民・市民の「知る権利」を尊重していない。

4。議論を避ける、議論ができない。
原子力事業者側から一方的な情報提供はあっても、ほとんど常に議論を避けようとする。あるいは、議論の仕方を知らない。結論ないし既成事実があって、それを押しつけるための「合意形成」のプロセスは議論ではない。

5。住民の意思を尊重しない。
住民投票で「ノー」の答えが出ても、「住民の理解不足」とか「国策」だと言い張るようでは、誰からも見捨てられるだろう。

6。唯原発主義。
電力会社はエネルギーへの取り組み をなぜもっと多様にフレキシブルにできないのか。最初に「原発」という結論があって、そのための正当化をやっているという印象しか持てない。

7。「原子力ファミリー」体質から抜けられない。
内部の意見の対立、特に核燃料サイクルについての評価の違いなどが、大いにあるはずなのに議論としてまったく外に出ないのは異常。これはまた責任の所在をあいまいにし、国民から見ると最も不透明感を抱く材料でもある。

発表は 4月10日 (午前)午後 9時 以降に願います。

EMBARGO UNTIL 9:00 (a.m.) p.m. April 10

§社会討論

So Many Reasons for Nuclear Facilities Being Deemed Unacceptable

Citizens' Nuclear Information Center J. Takagi

1. Lack of basic acknowledgement of potential risk.

A nuclear facility could potentially be a huge hazard, but nuclear industry people would not like to acknowledge this basic fact.

2. The nuclear industry always tries to evade confronting this intrinsic difficulty by spending huge some of money on subsidiaries and other nonessential things..

3. Unwillingness to publicize information. The basic position of the government and nuclear industry on information disclosure is that they disclose information only to facilitate public acceptance and they do not basically acknowledge the citizens' rights to know or freedom of information rights.

4. The nuclear industry tends to avoid arguments, and they even do not know often how to argue before the public.

5. The government and nuclear industry do not respect local residents' opinions. Even if they got a "No" answer from the residents in a referendum, they say, "national policy is superior, and the residents' understanding is insufficient". The truth is that the government and the utilities lack a full understanding what the residents think.

6. All-out pro-nuclear policy

I can hardly understand why Japanese nuclear utilities so obstinately concentrate on advocating for nuclear energy.

7. The government and nuclear industry form the so-called nuclear family and want to decide everything inside this circle. It seems to me quite anomalous that we can never hear diverse opinions from inside the nuclear industry at least officially on subjects like the nuclear cycle policy option or reactor type strategy on which there should be varying or even splitting opinions. This also makes very ambiguous where the responsibility lies in nuclear decision making and its implementation.

Subject: 年会講演
Date: Fri, 28 Mar 1997 13:19:12 +0900
From: jin-cnic@po.iijnet.or.jp (Jinzaburo Takagi)
To: annual@jaif.or.jp

社会討論

発表は 4月10日 午前 9時 以降に願います。

EMBARGO UNTIL 9:00 a.m. April 10

原産企画情報部様
講演本文を送ります。よろしく。
原子力施設が嫌われるこれだけの理由

原子力資料情報室　高木仁三郎

1。危険性の認識の欠落。
原子力施設は巨大な放射能放出の可能性を常に秘めた潜在的に危険な施設であり、放射性廃棄物の発生と合わせて、それ自体の本質において地域にメリットのない”迷惑施設”である。原子力事業者はしばしばこの当たり前の事実を認めようとせずに「安全」だけを強調し、最大の問題は自らも「まったくの安全施設」と思ってしまっているらしい点である。さらに言えば、この点でとうに住民、いや広く国民一般の信頼を失っているのに、その事実も認識できていない。相次ぐ動燃の失態はこのことを如実に示している。

2。金でその困難を回避しようとする。
それらの困難を、政府や事業者は各種の交付金や寄付金、諸便益で回避しようとする。しかし、それらは所詮「迷惑料」であり、原子力施設の地域へのメリットと称するものは、付随的なものにすぎない。大消費地で使う電力以外のもの、つまり地域への創造的寄与は、原子力施設にはないし、「原子力文化」などというものも存在しない。「金で解決する」やり方は、むしろ地域をゆがめており、金を投入すればするほど人心は離れるが、このことも気づいていない。

3。情報を公開しない。
政府や電力会社の情報公開の度合いは、現在でもきわめて不十分である。その事例は、数多く具体的に指摘できるが、基本的な問題は、未だに「広報」という枠組みでしか情報公開の問題を考えていないことだ。提供される情報は、生の事実ではなく、広報的に味付けされた説明、多くは「理解と協力」を求めるための政府や事業者の立場の擁護にすぎない。人々が求めているのは、結果についての説明ではなく、プロセスに参加するための情報だ。住民・市民は本来政策決定の主体であるはずで、そのために必要なすべての情報を選別なく知る権利を持っているし、自らの生命を守るためにも、情報の完全な公開を求めている。しかし、この基本的な権利が尊重されておらず、「商業機密」の保護が優位に置かれいる。この点を大多数の住民・市民は見抜いており、「原子力施設を嫌う」大きな理由を形成していると思う。
さらに言えば、記者会見などで報告される内容には、市民には理解しがたい技術用語や数字がそのまま使われるケースが多い。

4。議論を避ける、議論ができない。
政府や原子力事業者側から一方的な情報提供はあっても、ほとんど常に議論を避けようとする。長い間、一般の人々と真剣な議論をして相手の納得を得るというプロセスを怠ってきたため、議論の仕方を知らないのではないかという印象を受ける（円卓会議でもこの感が強かった）。これは議論の技術の問題でなく、議論するということに対する誠意の問題である。
プルサーマル問題について言うと、昨年1月の三県知事の提案には「プルサーマル計画やバックエンド政策の将来的な全体像をこれらから派生する諸問題も含めて具体的に明確」に提示することが、国に対して求められていた。円卓会議での了解もそうであったと思う。これには当然、メリッと、デメリット論を詳細に検討する作業がふくまれていたはずだ。政府はこれに答える責任があったのに、総合エネ調原子力部会中間報告をはじめとするこの間の一連の動きは、明に「国策」の押しつけで、「派生する諸問題」の検討などまったくない。結論ないし既成事実があって、それを押しつけるために行う「合意形成」のプロセスは議論ではない。

5。住民の意思を尊重しない。
住民投票で「ノー」の答えが出ても、「住民の無知・理解不足」とか「国策」だと言い張るようでは、住民（さらには国民）軽視ないし無視であり、最終的には誰からも見捨てられるだろう。むしろ政府や電力会社の側こそが、住民の気持ちや知識について著しく無知であり、理解不足である。これは、上の4。の問題とも密接に関係している。

6。唯原発主義。
政府や電力会社はエネルギー問題への取り組み をなぜもっと多様にフレキシブルにできないのか。最初に「原発」という結論があって、そのための正当化をやっているという印象しか持てない。原発によってすべてエネルギー問題が片づくはずもなく、また、原子力長期計画などまったく非現実的で破綻を来しているのに、いつまで看板が掲げられたままになっている。しかも、これが企業の事業活動という枠組みを超えて、「国策」という位置づけをもって強要される。このやり方はうさん臭いし、これでは、国民は信頼しない。その硬直さの度合いは、世界の他の国と比べても異常である。

７。「原子力ファミリー」体質から抜けられない。

内部の意見の対立、特に核燃料サイクルについての評価の違いなどが、大いにあるはずなのに議論としてまったく外に出ないのは異常である。「国策」ないし企業への忠誠ということで、「本音」が封じられているのか。長い間の「原子力村」の閉鎖性の中で、それが当たり前になっているのか。いずれにせよ、これはまた事故や計画破綻などの責任の所在をあいまいにし、国民から見ると最も不透明感を抱く材料でもある。また、反対論や異なる意見に真摯に耳を傾けようとしない。最近は、各種の懇談会がごく一部の「反対派」に門戸を開いたが、その人選、構成など結局は官僚まかせ、不透明限りがない。

原子力施設が嫌われるこれだけの理由

原子力資料情報室　高木仁三郎

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原子力施設は巨大な放射能放出の可能性を常に秘めた潜在的に危険な施設であり、放射性廃棄物の発生と合わせて、それ自体の本質において地域にメリットのない”迷惑施設”である。原子力事業者はしばしばこの当たり前の事実を認めようとせずに「安全」だけを強調し、最大の問題は自らも「まったくの安全施設」と思ってしまっているらしい点である。さらに言えば、この点でとうに住民、いや広く国民一般の信頼を失っているのに、その事実も認識できていない。相次ぐ動燃の失態はこのことを如実に示している。

２。金でその困難を回避しようとする。

それらの困難を、政府や事業者は各種の交付金や寄付金、諸便益で回避しようとする。しかし、それらは所詮「迷惑料」であり、原子力施設の地域へのメリットと称するものは、付随的なものにすぎない。大消費地で使う電力以外のもの、つまり地域への創造的寄与は、原子力施設にはないし、「原子力文化」などというものも存在しない。「金で解決する」やり方は、むしろ地域をゆがめており、金を投入すればするほど人心は離れるが、このことも気づいていない。

３。情報を公開しない。

政府や電力会社の情報公開の度合いは、現在でもきわめて不十分である。その事例は、数多く具体的に指摘できるが、基本的な問題は、未だに「広報」という枠組みでしか情報公開の問題を考えていないことだ。提供される情報は、生の事実ではなく、広報的に味付けされた説明、多くは「理解と協力」を求めるための政府や事業者の立場の擁護にすぎない。人々が求めているのは、結果についての説明ではなく、プロセスに参加するための情報だ。住民・市民は本来政策決定の主体であるはずで、そのために必要なすべての情報を選別なく知る権利を持っているし、自らの生命を守るためにも、情報の完全な公開を求めている。しかし、この基本的な権利が尊重されておらず、「商業機密」の保護が優位に置かれいる。この点を大多数の住民・市民は見抜いており、「原子力施設を嫌う」大きな理由を形成していると思う。

さらに言えば、記者会見などで報告される内容には、市民には理解しがたい技術用語や数字がそのまま使われるケースが多い。

４。議論を避ける、議論ができない。

政府や原子力事業者側から一方的な情報提供はあっても、ほとんど常に議論を避けようとする。長い間、一般の人々と真剣な議論をして相手の納得を得るというプロセスを怠ってきたため、議論の仕方を知らないのではないかという印象を受ける（円卓

会議でもこの感が強かった）。これは議論の技術の問題でなく、議論するということに対する誠意の問題である。

プルサーマル問題について言うと、昨年１月の三県知事の提案には「プルサーマル計画やバックエンド政策の将来的な全体像をこれらから派生する諸問題も含めて具体的に明確」に提示することが、国に対して求められていた。円卓会議での了解もそうであったと思う。これには当然、メリッと、デメリット論を詳細に検討する作業がふくまれていたはずだ。政府はこれに答える責任があったのに、総合エネ調原子力部会中間報告をはじめとするこの間の一連の動きは、明に「国策」の押しつけで、「派生する諸問題」の検討などまったくない。結論ないし既成事実があって、それを押しつけるために行う「合意形成」のプロセスは議論ではない。

５。住民の意思を尊重しない。

住民投票で「ノー」の答えが出ても、「住民の無知・理解不足」とか「国策」だと言い張るようでは、住民（さらには国民）軽視ないし無視であり、最終的には誰からも見捨てられるだろう。むしろ政府や電力会社の側こそが、住民の気持ちや知識について著しく無知であり、理解不足である。これは、上の４。の問題とも密接に関係している。

６。唯原発主義。

政府や電力会社はエネルギー問題への取り組み をなぜもっと多様にフレキシブルにできないのか。最初に「原発」という結論があって、そのための正当化をやっているという印象しか持てない。原発によってすべてエネルギー問題が片づくはずもなく、また、原子力長期計画などまったく非現実的で破綻を来しているのに、いつまで看板が掲げられたままになっている。しかも、これが企業の事業活動という枠組みを超えて、「国策」という位置づけをもって強要される。このやり方はうさん臭いし、これでは、国民は信頼しない。その硬直さの度合いは、世界の他の国と比べても異常である。

７。「原子力ファミリー」体質から抜けられない。

内部の意見の対立、特に核燃料サイクルについての評価の違いなどが、大いにあるはずなのに議論としてまったく外に出ないのは異常である。「国策」ないし企業への忠誠ということで、「本音」が封じられているのか。長い間の「原子力村」の閉鎖性の中で、それが当たり前になっているのか。いずれにせよ、これはまた事故や計画破綻などの責任の所在をあいまいにし、国民から見ると最も不透明感を抱く材料でもある。また、反対論や異なる意見に真摯に耳を傾けようとしない。最近は、各種の懇談会がごく一部の「反対派」に門戸を開いたが、その人選、構成など結局は官僚まかせ、不透明限りがない。

原子力発電所立地と地域振興（柏崎市の例）

柏崎商工会議所専務理事
内藤　信寛

1. 柏崎市の概要

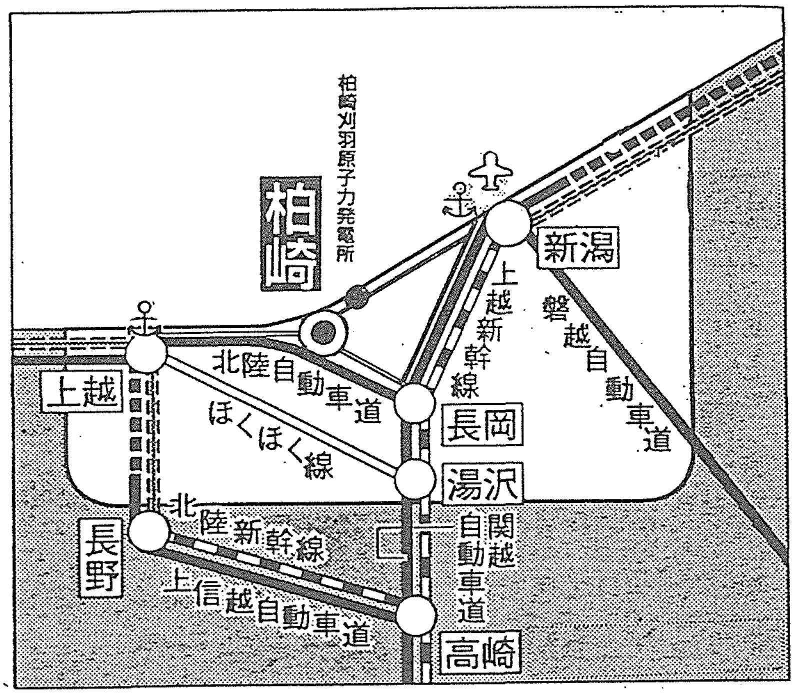
位　置　　新潟県のほぼ中央、日本海に面し、一方を海、三方を山に囲まれ独立した生活、経済圏を形成している。
東京へ約３００km、北陸・関越自動車道で約３時間、ＪＲ信越本線・上越新幹線で２時間１０分の距離にある。

面　積　　３１９．２５k㎡
（海岸線３６km）

人　口　　８８，７７１人
（H 8.4.30住基人口）

産　業　　工業製品出荷額
約 3,000億円

商業販売額
約 2,000億円



2. 柏崎とエネルギーとの係わり

① 日本の石油産業発祥の地

② 構造性天然ガスの産地

③ 世界一の原子力発電所

3. 柏崎刈羽原子力発電所の概要

■全体計画

設置位置　　柏崎市及び刈羽村

建設用地面積　　約４２０万㎡（柏崎市約３１０万㎡　刈羽村約１１０万㎡）

最終開発規模　　８２１．２万Ｋｗ

■計画概要

項目＼号機		1号機	2号機	5号機	3号機	4号機	6号機	7号機
炉型式		沸騰水型軽水炉	〃	〃	〃	〃	〃	〃
発電出力		110万kW	〃	〃	〃	〃	135.6万kW	〃
建設工事費概算		約4,756億円	約3,000億円	約3,560億円	約3,250億円	約3,344億円	約4,300億円	約3,700億円
電源開発調整審議会承認年月日		49.7.4	56.3.26	56.3.26	60.3.27	60.3.27	63.3.18	63.3.18
原子炉設置認可申請年月日		50.3.20	56.5.11	56.5.11	60.4.11	60.4.11	63.5.23	63.5.23
原子炉設置認可年月日		52.9.1	58.5.6	58.5.6	62.4.9	62.4.9	3.5.15	3.5.15
工期	着工年月日	53.12.1	58.10.26	58.10.26	62.7.1	63.2.5	3.9.17	4.2.3
	営業運転開始年月日	60.9.18	2.9.28	2.4.10	5.8.11	6.8.11	8.11.7	9.7予定

4. 原子力発電所立地経過の概要

１９６８（Ｓ４３）年	○ 通産省の委託により、新潟県が柏崎市荒浜地区に原子力発電所立地調査を実施
	○ 柏崎市議会に原子力発電所誘致研究委員会発足
１９６９（Ｓ４４）年	○ 柏崎市議会、原子力発電所誘致決議を可決
	○ 柏崎市商工会議所議員総会で誘致議決
	○ 柏崎刈羽原発誘致対策協議会設立
	○ 東京電力㈱が柏崎刈羽地区に進出発表（原子力準備事務所設置）
１９７０（Ｓ４５）年	○ 用地の斡旋妥結、買収開始
	○ 柏崎商工会議所原発誘致対策特別委員会設置
１９７２（Ｓ４７）年	○ 原子力発電所建設と地域開発を推進する会発足
１９７４（Ｓ４９）年	○ 漁業補償妥結
	○ 電源三法公布
	○ 第６５回電源開発調整審議会 １号機（１１０万Ｋｗ）決定
１９７６（Ｓ５１）年	○ 原発建設推進団体連絡協議会発足
１９７７（Ｓ５２）年	○ １号機ＢＷＲ１１０万Ｋｗ設置許可
１９７８（Ｓ５３）年	○ １号機着工
１９７９（Ｓ５４）年	○ 米国スリーマイルアイランド原子力発電所事故発生
１９８０（Ｓ５５）年	○ 通産省２・５号炉設置第一次公開ヒア開催
	○ 柏崎商工会議所電源立地ＰＡ事業導入
１９８１（Ｓ５６）年	○ 日本原電敦賀発電所放射能漏洩事故判明
	○ 通産省、原子力発電施設等周辺地域交付金制度発足
１９８３（Ｓ５８）年	○ 安全協定締結（県・市・村・東電）
１９８４（Ｓ５９）年	○ 県、関係市町村、原子力防災訓練（第１回）
１９８５（Ｓ６０）年	○ １号機営業運転開始
１９８６（Ｓ６１）年	○ ソ連チェルノブイル原発事故発生
１９９４（Ｈ ６）年	○ ４号機ＢＷＲ１１０万Ｋｗ営業運転開始 総体出力５５０万Ｋｗ（日本最大）
１９９７（Ｈ ９）年	○ ７月、７号機ＡＢＷＲ１３５．６万Ｋｗ営業運転開始（予定）により、総体出力８２１．２万Ｋｗで世界最大の原子力発基地

5. 原子力発電所誘致の理由

(1) 広大な荒浜砂丘の開発（有効活用）

(2) 原発建設をバネに地域の活性化をはかる（陸の孤島からの脱却）

(3) 国のエネルギー政策への貢献

6. 電源立地の効果

(1) 人口の増加

(2) 雇用の増加

(3) 市民所得（生活）の向上

(4) 産業への波及効果

① 建設工事への地元企業の参加

② メンテナンス等、新規事業機会の創出

③ 技術移転

④ 消費・購買活動

(5) 電源財源による財政力の向上とインフラ整備

① 電源立地促進対策交付金（１～７号機分、約２４２億円）

② 固定資産（償却資産）税（Ｓ６１～Ｈ１７年　約１，４８４億円）

③ 発電地域長期発展交付金（平成９年度　４億４，０００万円）

(6) 電気料金の割引

（一般家庭１８，９１２円／口・年、企業９，４５６円／Ｋｗ・年）

（全国６８０都市住み良さランキング第７位……東洋経済新報社）

7. エネルギー都市を目指して

柏崎刈羽原子力発電所は、平成９年７月に最終号機である７号機が、営業運転を開始することにより、昭和４４年の市議会誘致決議以来３０年の年月を費やした巨大プロジェクトの建設計画が完了する。

柏崎市は、世界一のエネルギー基地として国のエネルギー確保の上で大きな役割を担うことになる。今後は一層、環境保全、安全確保、地域振興を進め、エネルギー都市のモデル立地に向けて新たなスタートを期したい。

(1) 市民ひとりひとりが日本のエネルギーを支えていることを誇りに思うまち。

(2) 発電所と地域との共生をはかりつつも、常に相互の緊張関係を保持する。

(3) 原子力、エネルギーに関する情報発信を行い、消費地との交流を促進する。

(4) 世界一の原子力発電所にふさわしい防災対策。

(5) 地球規模での環境を考える研究機関の設置（誘致）。

(6) 地域の大学との連携による原子力安全システム研究機関の設置（誘致）。

(7) 更なる地域振興の促進と財源の確保。

- 電気料金の思い切った割引制度
- 発電所施設・整備の耐用年数の延長
- 電力移出市町村交付金の新設

原子力施設立地　：　問題点および展望

１９９７年4月１０日

舛添　要一

原子力発電を巡る議論の前提として、世界のエネルギー事情について理解しておく必要がある。まず供給面で、石炭、石油、天然ガスなどのエネルギー資源の埋蔵量がどれくらいかを知っておかねばならない。これまでの２次にわたる石油ショックは、供給面から引き起こされたものである。次に、需要面であるが、急速な経済発展に伴って、アジアのエネルギー需要が急増している。第３次石油危機は、この需要の急増によって引き金を引かれるのではあるまいか。

以上の様な基本的情報が広く国民の間に共有されないと、原子力発電の必要性について住民を説得することが困難となる。エネルギー需給というとき、生活様式、生産様式が大きく関わってくるので、原発にたいする態度決定は、現在の科学技術の恵沢を享受し続けるか、前近代的生活への逆行（そこまで極端でなくとも、少なくとも今の多エネルギー消費型の生き方の見直し）するかの選択でもあることを明言してもよいのではあるまいか。

原子力施設を建設しようとするとき、地元の住民の反発が予想されるが、いわゆるPublic Acceptanceについては、以下のような点が考慮に値する。

（１）原子力発電についての国民全体の認知度、評価度

（２）原子力施設、軍事基地などの存在する町にたいする国民全体の認知度、評価度

（３）立地する町の豊かさ、他の重要産業の有無

（４）安全対策、環境対策などの実施度合

（５）危機管理体制の整備度合

最近では、巻町の例に見られるように、住民投票による決定が大きな意味を持ってくるので、この問題についても考察が必要である。条例に基づく住民投票は、法的な拘束力は持たないが、政治的には重みがあるので、むしろ住民投票を現在の日本の法体系の中に組み入れる工夫が必要である。

Nuclear Facilities Siting — Problems and Perspectives

Yoichi Masuzoe
Political Scientist

As a precondition for discussion of nuclear power generation, it is necessary to understand the world energy situation. First, we should know the estimated amount of energy reserves, such as coal, oil, and natural gas. The past two oil crises resulted from concerns over the limited supply of energy resources. Next, with rapid economic growth in Asia, energy demand has sharply increased. A third oil crisis could be triggered by this sharp increase in energy demand.

It is difficult to convince people of the necessity of nuclear power generation, without such basic information being widely shared. Since energy supply and demand is closely related to lifestyle and production methods, it may be right to declare that one's attitude toward nuclear generation is the choice of whether to continue to enjoy the benefits of today's technology or to go back to pre-modern life (or at least to reexamine today's energy-intensive lifestyle).

When a nuclear power plant is constructed, it is expected that local residents will resist it. Regarding so-called "public acceptance," it is important to consider the following points:

(1) The entire nation's understanding and evaluation of nuclear power generation
(2) The entire nation's understanding and evaluation of municipalities where nuclear facilities and military bases exist
(3) The affluence of the municipality where a nuclear power plant is located; whether or not there are other important industries
(4) To what extent safety and environmental measures are implemented
(5) Whether or not a crisis management system is established

In recent years, public referendums have had significant effects, as in the case of Maki-machi. It is also necessary to consider this issue. A referendum based on a local ordinance is not legally binding, but politically very important. We should ,therefore, try to incorporate a referendum into the present Japanese legal system.